FINAL REPORT

SUBMITTED TO

JAY DORR
SAWTOOTH NATIONAL RECREATION AREA, KETCHUM, IDAHO
U.S. FOREST SERVICE

REGARDING

ESTABLISHMENT OF A LICHEN BIOMONITORING PROGRAM AND
BASELINE IN THE SAWTOOTH WILDERNESS AREA, SAWTOOTH
NATIONAL FOREST, IDAHO

COPY

PREPARED BY

LARRY L. ST. CLAIR Ph.D.
PROFESSOR OF BOTANY AND CURATOR OF NON-VASCULAR
CRYPTOGAMS
DEPARTMENT OF BOTANY AND RANGE SCIENCE
BRIGHAM YOUNG UNIVERSITY
PROVO, UTAH 84602

31 DECEMBER 1995
INTRODUCTION

PROJECT OBJECTIVES:

1. Identify and establish air quality bimonitoring reference sites in the Sawtooth Wilderness Area, Idaho. (note: This objective was accomplished in 1988 and 1989.)

2. Collect, curate, and identify lichen species from various habitats and substrates at each reference site. (note: This objective was accomplished in 1988 and 1989.)

3. Identify 3-5 pollution-sensitive lichen species at each reference site. Collect enough tissue of at least one sensitive indicator species (approximately 6-10 grams dry weight) from each reference site for elemental analyses. Rare species will not be sampled for analysis, but their distribution will be noted. (This objective was accomplished in 1988 and 1989.)

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 one documented pollution-sensitive species collected at each reference site. Samples will be analyzed using Proton Induced X-ray Emission (PIXE) techniques. (note: This objective applies specifically to the 1993 reevaluation samples collected from Farley Lake and Alpine Lake. However, elemental analysis samples from 1988 and 1989 are currently being reanalyzed using PIXE technology. These data will allow for more meaningful comparison between the 1988-1989 samples and the 1993 samples.)

5. Prepare and submit the final report by 31 December 1995. (note: the orginal report was submitted in 1989; however, I have updated all of the original information into a more comprehensive format.)

LICHENS AS BIOLOGICAL INDICATORS OF AIR QUALITY:

Protocol for using lichens as bioindicators of air quality is well documented (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 systems: 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 anlaysis of tissues from sensitive indicator species (St. Clair 1989; Wetmore 1989).

As lichens accumulate many different 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 and pollutant concentrations in excised portions of lichen thalli (Lawry & Hale 1981). Changes in lichen physiological processes indicate pollution-related damage long before other, more easily detectable changes in thallus color, morphology, or community structure become apparent (Fields & St. Clair 1984).

Lists of pollution-sensitive lichen species have commonly been 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. Pollution-related changes can then be documented by comparing follow-up data to original baseline data.
GENERAL HABITAT DESCRIPTION FOR THE SAWTOOTH NATIONAL RECREATION AREA AND THE SAWTOOTH WILDERNESS AREA:

The Sawtooth National Recreation Area was established in 1972 and consists of 754,000 acres. Included in the recreation area are three mountain ranges (the Sawtooths, White Clouds and Boulders) as well as parts of the Salmon River and Smoky Mountains. The mountain ranges of the Sawtooth National Recreation Area serve as headwaters for several major Idaho Rivers including, the Salmon, Big Wood, East Fork of the Salmon, Middle Fork of the Boise, and South Fork of the Payette. More than 400 lakes occur within the boundaries of the recreation area. The Sawtooth Wilderness Area includes 217,000 acres and encompasses most of the Sawtooth Range.

A significant portion of the recreation area is located within the southern portion of the Idaho batholith, called the Atlanta batholith. This granitic formation dominates central Idaho and was formed 70 to 90 million years ago during the late Cretaceous. Fresh exposures of this granite are pale gray and in some places slightly streaky. Weathered surfaces are pinkish brown due to an iron oxide stain that develops as the minerals weather. The most abundant mineral in this granite is a milky white feldspar; and the black flakes are biotite mica. The younger and much smaller Sawtooth batholith, formed 50 million years ago during the Eocene, forms a large part of the Sawtooth Range. Fresh exposures of the Sawtooth batholith granite are pink, with larger crystals and no streakiness.

Steep elevational gradients, massive rock outcrops compounded by the complicated topography of the recreation area has resulted in the development of a vast array of habitat types, ranging from alpine tundra and krummholz in the higher elevations to subalpine coniferous forests and riparian communities downslope.

LICHEN BIOMONITORING REFERENCE SITES IN THE SAWTOOTH WILDERNESS AREA:

A total of 6 air quality biomonitoring reference sites were established in Sawtooth Wilderness Area during the 1988-1989 field seasons. Two sites were reevaluated during the summer of 1993. Specifically, reference sites have been established at the following locations:


SITE #5: 1 August 1989. Idaho, Elmore County, Sawtooth Wilderness Area: along Middle Fork of the Boise River, 43° 49’ 23” north latitude; 115° 03’ 44” west longitude. Elevation: 1722 m (5650 feet).
SITE #6: 2 August 1989, Idaho, Elmore County, Sawtooth Wilderness Area: along Queen’s River Trail, 43° 51’ 40” north latitude; 115° 10’ 12” west longitude. Elevation: 1634 m (5360 feet).

METHODS

COLLECTION, CURATION, IDENTIFICATION, AND DEPOSITION OF LICHEN SPECIES:

Because lichen distribution is directly 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 substrate (bark, wood, soil, or rock).

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

Species were identified using standard lichen keys and taxonomic treatises. Standard 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 Cryptograms 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 abundance, available substrates, growth forms, documented/suspected pollution sensitivity and general distribution patterns, samples of one to several pollution sensitive indicator species were collected, returned to the Elemental Analysis Laboratory at BYU and PIXE analyses were performed.

At each reference site sufficient material of at least one sensitive, indicator species was collected for laboratory analysis (6-10 grams dry weight). All lichen material collected for elemental analyses was placed in Hubco cloth bags (to avoid contamination) and transported back to the BYU Herbarium of Nonvascular Cryptograms. Excess material is permanently stored in Hubco cloth bags in the elemental analysis collection at BYU. 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 samples. Clean, two gram samples of at least one 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 weighed in to 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 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 also prepared and analyzed using the same procedures.

RESULTS, OBSERVATIONS AND RECOMMENDATIONS

LICHEN MATERIAL COLLECTED FOR ELEMENTAL ANALYSES:

A total of 25 samples consisting of 5 species in 5 genera from three general substrates (conifer bark, conifer lignum and rock) were collected for elemental analyses. Proton Induced X-ray Emission (PIXE) techniques were used to analyze all samples. Below is a list of all of the elemental analysis samples by sample number (the first number represents the storage drawer and the second number represents the specimen bag number), species, substrate and reference site. All samples are stored in Hubco cloth bags in the elemental Analysis Collection at the Herbarium of Non-vascular Cryptogams at Brigham Young University, Provo, Utah. Samples marked with an "**" were collected in 1993 as part of the reevaluation study at Farley and Alpine lakes.

<table>
<thead>
<tr>
<th>Sample#</th>
<th>Taxa</th>
<th>Substrate</th>
<th>Reference site</th>
</tr>
</thead>
<tbody>
<tr>
<td>13-106</td>
<td>Dermatocarpon reticulatum</td>
<td>rock</td>
<td>1</td>
</tr>
<tr>
<td>13-107</td>
<td>Letharia vulpina</td>
<td>conifer bark</td>
<td>1</td>
</tr>
<tr>
<td>13-108</td>
<td>Dermatocarpon reticulatum</td>
<td>rock</td>
<td>2</td>
</tr>
<tr>
<td>13-109</td>
<td>Letharia vulpina</td>
<td>conifer lignum</td>
<td>2</td>
</tr>
<tr>
<td>14-110</td>
<td>Dermatocarpon reticulatum</td>
<td>rock</td>
<td>3</td>
</tr>
<tr>
<td>14-111</td>
<td>Letharia vulpina</td>
<td>conifer bark</td>
<td>4</td>
</tr>
<tr>
<td>14-112</td>
<td>Bryoria fremontii</td>
<td>conifer bark</td>
<td>5</td>
</tr>
<tr>
<td>14-113</td>
<td>Letharia vulpina</td>
<td>conifer bark</td>
<td>5</td>
</tr>
<tr>
<td>14-114</td>
<td>Bryoria fremontii</td>
<td>conifer bark</td>
<td>5</td>
</tr>
<tr>
<td>14-115</td>
<td>Bryoria fremontii</td>
<td>conifer bark</td>
<td>5</td>
</tr>
<tr>
<td>14-116</td>
<td>Letharia vulpina</td>
<td>conifer bark</td>
<td>5</td>
</tr>
<tr>
<td>15-117</td>
<td>Letharia vulpina</td>
<td>conifer bark</td>
<td>5</td>
</tr>
<tr>
<td>18-146</td>
<td>Letharia vulpina</td>
<td>conifer bark</td>
<td>5</td>
</tr>
<tr>
<td>18-147</td>
<td>Bryoria fremontii</td>
<td>conifer bark</td>
<td>6</td>
</tr>
<tr>
<td>18-148</td>
<td>Tuckermannopsis canadensis</td>
<td>conifer bark</td>
<td>5</td>
</tr>
<tr>
<td>19-149</td>
<td>Bryoria fremontii</td>
<td>conifer bark</td>
<td>6</td>
</tr>
<tr>
<td>19-150</td>
<td>Tuckermannopsis canadensis</td>
<td>conifer bark</td>
<td>5</td>
</tr>
<tr>
<td>19-151</td>
<td>Letharia vulpina</td>
<td>conifer lignum</td>
<td>3</td>
</tr>
<tr>
<td>24-193*</td>
<td>Dermatocarpon reticulatum</td>
<td>rock</td>
<td>1</td>
</tr>
<tr>
<td>24-194*</td>
<td>Umbilicaria vellea</td>
<td>rock</td>
<td>1</td>
</tr>
<tr>
<td>24-195*</td>
<td>Letharia vulpina</td>
<td>conifer lignum</td>
<td>1</td>
</tr>
<tr>
<td>24-196*</td>
<td>Dermatocarpon reticulatum</td>
<td>rock</td>
<td>2</td>
</tr>
<tr>
<td>24-197*</td>
<td>Letharia vulpina</td>
<td>conifer bark</td>
<td>2</td>
</tr>
<tr>
<td>24-198*</td>
<td>Umbilicaria vellea</td>
<td>rock</td>
<td>2</td>
</tr>
<tr>
<td>29-241a</td>
<td>Letharia vulpina</td>
<td>conifer lignum</td>
<td>5</td>
</tr>
<tr>
<td>29-241b</td>
<td>Letharia vulpina</td>
<td>conifer lignum</td>
<td>5</td>
</tr>
</tbody>
</table>
Pollution Sensitive Indicator Species by Reference Site:

Vicinity of Alpine Lake:

- Bryoria abbreviata (sensitive to ozone)
- Buellia punctata (intermediately sensitive to sulfur dioxide)
- Cladonia fimбриata (sensitive to intermediately sensitive to sulfur dioxide)
- Hypogymnia imshaugii (intermediately sensitive to ozone)
- Letharia columbiana (intermediately sensitive to ozone)
- Letharia vulgaris (intermediately sensitive to ozone)
- Melanelia exasperatula (intermediately sensitive to sulfur dioxide)
- Melanelia subbulivacea (intermediately sensitive to ozone)
- Parmeliopsis ambiguа (intermediately sensitive to sulfur dioxide)
- Peltigera canina (sensitive to ozone)
- Rhizocarpon geographicum (sensitive to flouride)

Vicinity of Farley Lake:

- Bryoria abbreviata (sensitive to ozone)
- Buellia punctata (intermediately sensitive to sulfur dioxide)
- Candelariella vitellina (intermediately sensitive to sulfur dioxide; sensitive to flouride)
- Cladonia fimбриata (sensitive to intermediately sensitive to sulfur dioxide)
- Letharia vulgaris (intermediately sensitive to ozone)
- Melanelia exasperatula (intermediately sensitive to sulfur dioxide)
- Ochrolechia androgyna (sensitive to sulfur dioxide)
- Parmeliopsis ambiguа (intermediately sensitive to sulfur dioxide)
- Peltigera canina (sensitive to ozone)
- Physcia caesia (intermediately sensitive to sulfur dioxide)
- Physcia dubia (sensitive to intermediately sensitive to flouride)
- Platismatia glauca (intermediately sensitive to sulfur dioxide)
- Pseudephebe pubescens (intermediately sensitive to ozone)
- Rhizocarpon geographicum (sensitive to flouride)
- Rhizoplaea chrysolaevica (sensitive to sulfur dioxide; sensitive to NOx/PAN)
- Rhizoplaea melanophthalma (sensitive to sulfur dioxide)
- Xanthoria candelaria (intermediately sensitive to sulfur dioxide)

Vicinity of North Alpine-Flytrip Basins:

- Acarospora chlorophana (sensitive to sulfur dioxide)
- Letharia columbiana (intermediately sensitive to ozone)
- Letharia vulgaris (intermediately sensitive to ozone)
- Parmeliopsis ambiguа (intermediately sensitive to sulfur dioxide)
- Phaeophyscia orbicularis (sensitive ozone; intermediately sensitive to sulfur dioxide; sensitive to flouride)
- Physcia caesia (intermediately sensitive to sulfur dioxide)
- Physcia dubia (sensitive to intermediately sensitive to flouride)
- Pseudephebe pubescens (intermediately sensitive to ozone)
- Rhizocarpon geographicum (sensitive to flouride)
- Rhizoplaea melanophthalma (sensitive to sulfur dioxide)
Middle Fork Boise River:

* Alectoria sarmentosa* (sensitive to ozone)
* Bryoria abbreviata* (sensitive to ozone)
* Bryoria fremontii* (sensitive to ozone)
* Buellia punctata* (intermediately sensitive to sulfur dioxide)
* Cladonia fimbriata* (sensitive to intermediately sensitive to sulfur dioxide)
* Hypocenomyce scalaris* (intermediately sensitive to sulfur dioxide)
* Hypogymnia imshaugii* (intermediately sensitive to ozone)
* Lecanora saligna* (intermediately sensitive to sulfur dioxide)
* Leptochidium alboclatatum* (sensitive to intermediately sensitive to ozone)
* Letharia columbiana* (intermediately sensitive to ozone)
* Letharia vulpina* (intermediately sensitive to ozone)
* Melanelia exasperatulae* (intermediatelys sensitive to sulfur dioxide)
* Ochrolechia androgyna* (sensitive to sulfur dioxide)
* Parmeliopsis ambiguus* (intermediately sensitive to sulfur dioxide)
* Peligeria canina* (sensitive to ozone)
* Phaeophyscia orbicularis* (sensitive to ozone; intermediately sensitive to sulfur dioxide; sensitive to flouride)
* Physcia dubia* (sensitive to intermediately sensitive to sulfur dioxide)
* Pseudephebe pubescens* (intermediately sensitive to ozone)
* Rhizocarpon disporum* (sensitive to flouride)
* Tuckermannopsis canadensis* (sensitive to ozone)
* Tuckermannopsis chlorophylla* (sensitive to sulfur dioxide)
* Tuckermannopsis merrillii* (sensitive to intermediately sensitive to ozone)
* Xanthoria fallax* (intermediately sensitive to sulfur dioxide; sensitive to NOx/PAN)

along Queen's River Trail:

* Alectoria sarmentosa* (sensitive to ozone)
* Bryoria abbreviata* (sensitive to ozone)
* Bryoria fremontii* (sensitive to ozone)
* Buellia punctata* (intermediately sensitive to sulfur dioxide)
* Callicium viride* (sensitive to ozone; intermediately sensitive to sulfur dioxide)
* Caloploca cerina* (sensitive to intermediately sensitive to sulfur dioxide)
* Candelariella vitellina* (intermediately sensitive to sulfur dioxide; sensitive to flouride)
* Cladonia fimbriata* (sensitive to intermediately sensitive to sulfur dioxide)
* Hypogymnia imshaugii* (intermediately sensitive to ozone)
* Letharia colubrana* (intermediately sensitive to ozone)
* Letharia vulpina* (intermediately sensitive to ozone)
* Melanelia subolivacea* (intermediately sensitive to ozone)
* Ochrolechia androgyna* (sensitive to sulfur dioxide)
* Parmeliopsis ambiguus* (intermediately sensitive to sulfur dioxide)
* Parmeliopsis hyperopta* (intermediately sensitive to sulfur dioxide)
* Peligeria canina* (sensitive to ozone)
* Physcia dubia* (sensitive to intermediately sensitive to flouride)
* Rhizocarpon geographicum* (sensitive to flouride)
* Tuckermannopsis merrillii* (sensitive to intermediately sensitive to ozone)
* Usnea subfloridana* (sensitive to intermediately sensitive to sulfur dioxide)
* Xanthoria candelaria* (intermediately sensitive to sulfur dioxide)
CHECKLIST OF LICHEN SPECIES FROM SAWTOOTH WILDERNESS AREA:

*Acarospora chlorophana* (Wahlenb. ex Ach.) Massal.
- Growth form: Crustose (with effigurate margins)
- Substrate: rock
- Site(s): vicinity of North Alpine-Flytrip Basins
- Relative abundance: locally common
- Pollution sensitivity: sensitive to sulfur dioxide
- Comments: none
- Deposition of specimen: BYU Herbarium: BRY C-31425

*Acarospora fuscata* (Nyl.) Arnold
- Growth form: Crustose
- Substrate: rock
- Site(s): vicinity of North Alpine-Flytrip Basins
- Relative abundance: rare to locally common
- Pollution sensitivity: Unknown
- Comments: none
- Deposition of specimen: BYU Herbarium: BRY C-31426

*Alectoria sarmentosa* (Ach.) Ach.
- Growth form: Fruticose
- Substrate: Douglas Fir
- Site(s): along Queen's River Trail, Middle Fork Boise River
- Relative abundance: locally common to abundant
- Pollution sensitivity: sensitive to ozone (Ryan 1990)
- Comments: none
- Deposition of specimens: BYU Herbarium: BRY C-31308, BRY C-31410

- Growth form: Crustose (with effigurate margins)
- Substrate: rock
- Site(s): Middle Fork Boise River
- Relative abundance: rare
- Pollution sensitivity: Unknown
- Comments: none
- Deposition of specimens: BYU Herbarium: BRY C-31362

*Aspicilia cinerea* (L.) Körber
- Growth form: Crustose
- Substrate: rock
- Site(s): Middle Fork Boise River
- Relative abundance: rare to locally common
- Pollution sensitivity: Unknown
- Comments: none
- Deposition of specimen: BYU Herbarium: BRY C-31379
**Aspicilia desertorum** (Krempelh.) Mereschk.
- Growth form: Crustose
- Substrate: rock
- Site(s): vicinity of North Alpine-Flytrip Basins
- Relative abundance: rare to locally common
- Pollution sensitivity: Unknown
- Comments: none
- Deposition of specimens: BYU Herbarium: BRY C-31430

**Bellemerea alpina** (Sommerf.) Clauz. & Roux
- Growth form: Crustose
- Substrate: rock
- Site(s): vicinity of North Alpine-Flytrip Basins, vicinity of Alpine Lake, vicinity of Farley Lake
- Relative abundance: locally common
- Pollution sensitivity: Unknown
- Comments: none
- Deposition of specimen: BYU Herbarium: BRY C-31428, BRY C-31481, BRY C-32153

**Bellemerea cinereorufescens** (Ach.) Clauz. & Roux
- Growth form: Crustose
- Substrate: rock
- Site(s): Middle Fork Boise River, vicinity of Farley Lake
- Relative abundance: rare to locally common
- Pollution sensitivity: Unknown
- Comments: none
- Deposition of specimens: BYU Herbarium: BRY C-31370, BRY C-32154

**Biatora vernalis** (L.) Fr.
- Growth form: Crustose
- Substrate: conifer bark, lignum
- Site(s): vicinity of Farley Lake, along Queen's River Trail, Middle Fork Boise River
- Relative abundance: rare
- Pollution sensitivity: Unknown
- Comments: none
- Deposition of specimen: BYU Herbarium: BYU Herbarium: BRY C-31306, BRY C-31395

**Brodia oregonica** (Krog) Goward
- Growth form: Foliose
- Substrate: rock
- Site(s): vicinity of north Alpine-Flytrip Basins
- Relative abundance: rare to locally common
- Pollution sensitivity: Unknown
- Comments: none
- Deposition of specimen: BYU Herbarium: BRY C-31431
**Bryoria abbreviata** (Müll. Arg.) Brodo & D. Hawksw.
- Growth form: Fruticose
- Substrate: Lodgepole Pine bark, Douglas Fir
- Site(s): vicinity of Alpine Lake, vicinity of Farley Lake, along Queen's River Trail, Middle Fork Boise River
- Relative abundance: rare to locally common
- Pollution sensitivity: sensitive to ozone (Ryan 1990)
- Comments: none
- Deposition of specimen: BYU Herbarium: BRY C-31329, BRY C-31404, BRY C-32152, BRY C-32153, BRY C-32156

**Bryoria fremontii** (Tuck.) Brodo & D. Hawksw.
- Growth form: Fruticose
- Substrate: Douglas Fir, Lodgepole Pine
- Site(s): along Queen's River Trail, Middle Fork Boise River
- Relative abundance: common to locally abundant
- Pollution sensitivity: sensitive to ozone (Ryan 1990)
- Comments: none
- Deposition of specimen: BYU Herbarium: BRY C-31421, BRY C-31352, BRY C-31403

**Bryoria fusescens** (Gyelnik) Brodo & C. Hawksw.
- Growth form: Fruticose
- Substrate: conifer bark
- Site(s): along Queen's River Trail
- Relative abundance: locally common
- Pollution sensitivity: intermediately sensitive to sulfur dioxide (Ryan 1990)
- Comments: none
- Deposition of specimen: BYU Herbarium: BRY C-32162

**Buellia punctata** (Hoffm.) Massal.
- Growth form: Crustose
- Substrate: lignum, Douglas Fir
- Site(s): vicinity of Alpine Lake, vicinity of Farley Lake, along Queen's River, Middle Fork Boise River
- Relative abundance: rare to locally common
- Pollution sensitivity: intermediately sensitive to sulfur dioxide (Ryan 1990)
- Comments: none
- Deposition of specimen: BYU Herbarium: BRY C-31309a, BRY C-31309b, BRY C-31393

**Calicium viride** Pers.
- Growth form: Crustose
- Substrate: Douglas Fir
- Site(s): along Queen's River Trail
- Relative abundance: rare
- Pollution sensitivity: sensitive to ozone; intermediately sensitive to sulfur dioxide (Ryan 1990)
- Comments: none
- Deposition of specimen: BYU Herbarium: BRY C-31311
Caloplaca cerina (Ehrh. ex Hedwig) Th. Fr.
Growth form: Crustose (absent)
Substrate: Aspen
Site(s): along Queen's River Trail
Relative abundance: rare
Pollution sensitivity: sensitive to intermediately sensitive to sulfur dioxide (Wetmore 1987)
Comments: none
Deposition of specimens: BYU Herbarium: BYU Herbarium: BRY C-32161

Caloplaca epithallina Lyng
Growth form: Crustose
Substrate: epiphytic, growing over other lichens
Site(s): vicinity of Flytrip Basin Pass
Relative abundance: rare
Pollution sensitivity: Unknown
Comments: none
Deposition of specimen: BYU Herbarium: BRY C-31427b

Caloplaca holocarpa (Hoffm.) Wade
Growth form: Crustose (absent)
Substrate: Douglas Fir
Site(s): vicinity of Farley Lake
Relative abundance: rare to locally common
Pollution sensitivity: Unknown
Comments: none
Deposition of specimen: BYU Herbarium: BRY C-32157

Caloplaca jungermanniæ (Vahl) Th. Fr.
Growth form: Crustose (absent)
Substrate: detritus
Site(s): vicinity of North Alpine-Flytrip Basins
Relative abundance: rare
Pollution sensitivity: Unknown
Comments: none
Deposition of specimens: BYU Herbarium: BRY C-31433

Caloplaca stillicidiaum (Vahl) Lyng
Growth form: Crustose
Substrate: moss over soil
Site(s): along Queen's River Trail
Relative abundance: rare to locally common
Pollution sensitivity: Unknown
Comments: none
Deposition of specimens: BYU Herbarium: BRY C-31318

Caloplaca tiroliensis Zahlbr.
Growth form: Crustose
Substrate: detritus, moss over rock
Site(s): vicinity of Flytrip Basin Pass, Middle Fork Boise River
Relative abundance: rare to locally common
Pollution sensitivity: Unknown
Comments: none
Deposition of specimen: BYU Herbarium: BRY C-31373
Candelariella rosulans (Müll. Arg.) Zahlbr.
Growth form: Crustose
Substrate: rock, soil, moss over rock
Site(s): vicinity of North Alpine-Flytrip Basins
Relative abundance: rare to locally common
Pollution sensitivity: Unknown
Comments: none
Deposition of specimen: BYU Herbarium: BRY C-31434

Candelariella vitellina (Hoffm.) Müll
Growth form: Crustose
Substrate: Douglas Fir
Site(s): vicinity of Farley Lake, along Queen's River Trail
Relative abundance: rare to locally common
Pollution sensitivity: intermediately sensitive to sulfur dioxide; sensitive to flouride (Ryan 1990)
Comments: none
Deposition of specimens: BYU Herbarium: BRY C-32161, BRY C-32163

Catapyrenium squamulosum (Ach.) Breuss
Growth form: Squamulose
Substrate: soil
Site(s): vicinity of North Alpine Basin
Relative abundance: rare to locally common
Pollution sensitivity: Unknown
Comments: none
Deposition of specimen: BYU Herbarium: BRY C-31435

Cladonia cervinornis (Ach.) Flotow subsp. verticillata (Hoffm.) Ahti
Growth form: Squamulose (with podetia)
Substrate: soil
Site(s): along Queen's River Trail
Relative abundance: rare to locally common
Pollution sensitivity: Unknown
Comments: none
Deposition of specimens: BYU Herbarium: BRY C-32158

Cladonia chlorophaea (Flörke ex Sommerf.)
Growth form: Squamulose (with Podetia)
Substrate: soil
Site(s): vicinity of Alpine Lake, vicinity of Farley Lake
Relative abundance: locally common to abundant
Pollution sensitivity: Unknown
Comments: none
Deposition of specimen: BYU Herbarium: BRY C-31485

Cladonia deformis (L.) Hoffm.
Growth form: Squamulose (with podetia)
Substrate: detritus
Site(s): Middle Fork Boise River
Relative abundance: rare
Pollution sensitivity: Unknown
Comments: none
Deposition of specimens: BYU Herbarium: BRY C-31343
**Cladonia fimbriata** (L.) Fr.
Growth form: Squamulose (with podetia)
Substrate: decomposing wood, Douglas Fir, moss over soil, soil, moss
Site(s): along Queen's River Trail, Middle Fork Boise River, vicinity of Alpine Lake, vicinity of Farley Lake
Relative abundance: locally common
Pollution sensitivity: sensitive to intermediately sensitive to sulfur dioxide (Ryan 1990)
Comments: none
Deposition of specimen: BYU Herbarium: BRY C-31305, BRY C-31355, BRY C-31419, BRY C-31483, BRY C-31484, BRY C-32157, BRY C-32162

**Cladonia poccilium** (Ach.) O. Rich
Growth form: Squamulose (with podetia)
Substrate: soil
Site(s): vicinity of North Alpine-Flytrip Basins
Relative abundance: rare to locally common
Pollution sensitivity: Unknown
Comments: none
Deposition of specimen: BYU Herbarium: BRY C-31436

**Cladonia pyxidata** (L.) Hoffm.
Growth form: Squamulose
Substrate: soil, bark
Site(s): vicinity of Farley Lake
Relative abundance: locally common
Pollution sensitivity: sensitive to ozone (Ryan 1990)
Comments: none
Deposition of specimen: BYU Herbarium: BRY C-32164

**Cyphellum fucissile** (Ach.) Ach.
Growth form: Crustose
Substrate: Douglas Fir, burned wood, lignum
Site(s): vicinity of North Alpine-Flytrip Basins, vicinity of Farley Lake, Middle Fork Boise River
Relative abundance: rare to locally common
Pollution sensitivity: Unknown
Comments: none
Deposition of specimen: BYU Herbarium: BRY C-31353, BRY C-31413, BRY C-31437, BRY C-32163

**Dermatocarpon miniatum** (L.) Mann
Growth form: Foliose (umbilicate)
Substrate: rock
Site(s): vicinity of Alpine Lake, vicinity of Farley Lake, vicinity of North Alpine-Flytrip Basins, Middle Fork Boise River
Relative abundance: locally common
Pollution sensitivity: Unknown
Comments: none
Deposition of specimen: BYU Herbarium: BRY C-31372, BRY C-31439
**Dermatocarpon reticulatum** Magnusson
- Growth form: Foliose (umbilicate)
- Substrate: rock
- Site(s): vicinity of Alpine Lake, vicinity of Farley Lake
- Relative abundance: locally common
- Pollution sensitivity: Unknown
- Comments: none
- Deposition of specimens: BYU Herbarium: BRY C-31486, BRY C-32165

**Hypocenomyce scalaris** (Ach. ex Liljeblad) M. Choisy
- Growth form: Squamulose
- Substrate: burned wood
- Site(s): Middle Fork Boise River
- Relative abundance: rare
- Pollution sensitivity: intermediately sensitive to sulfur dioxide (Ryan 1990)
- Comments: none
- Deposition of specimens: BYU Herbarium: BRY C-31412

**Hypogymnia imshaugii** Krog
- Growth form: Foliose
- Substrate: conifer bark, Douglas Fir
- Site(s): vicinity of Alpine Lake, along Queen's River Trail, Middle Fork Boise River
- Relative abundance: locally common
- Pollution sensitivity: intermediately sensitive to ozone (Ryan 1990)
- Comments: none
- Deposition of specimen: BYU Herbarium: BRY C-31303, BRY C-31335, BRY C-31347, BRY C-32164

**Lecanora argentea** (Ach.) Malme
- Growth form: Crustose
- Substrate: Douglas Fir
- Site(s): Middle Fork Boise River, along Queen's River Trail
- Relative abundance: rare to locally common
- Pollution sensitivity: Unknown
- Comments: none
- Deposition of specimens: BYU Herbarium: BRY C-31416, BRY C-32165

**Lecanora argopholis** (Ach.) Ach.
- Growth form: Crustose
- Substrate: rock
- Site(s): vicinity of North Alpine Basin, vicinity of Flytrip Basin Pass, Middle Fork Boise River
- Relative abundance: rare to locally common
- Pollution sensitivity: Unknown
- Comments: none
- Deposition of specimen: BYU Herbarium: BRY C-31390
**Lecanora cenisia** Ach.
- Growth form: Crustose
- Substrate: rock
- Site(s): along Queen's River Trail, Middle Fork Boise River, vicinity of North Alpine-Flytrip Basins
- Relative abundance: rare
- Pollution sensitivity: Unknown
- Comments: none
- Deposition of specimens: BYU Herbarium: BRY C-31322, BRY C-31377, BRY C-31444

**Lecanora christoi** W. Weber
- Growth form: Crustose (with effigurate margins)
- Substrate: rock
- Site(s): Middle Fork Boise River
- Relative abundance: rare
- Pollution sensitivity: Unknown
- Comments: none
- Deposition of specimens: BYU Herbarium: BRY C-31394

**Lecanora hagenii** (Ach.) Ach.
- Growth form: Crustose (absent)
- Substrate: over Selaginella, lignum, detritus, polypore
- Site(s): vicinity of North Alpine-Flytrip Basins, along Queen's River Trail
- Relative abundance: locally common
- Pollution sensitivity: Unknown
- Comments: none
- Deposition of specimen: BYU Herbarium: BRY C-31445, BRY C-31448, BRY C-32168

**Lecanora impudens** Degel.
- Growth form: Crustose
- Substrate: lignum, Douglas Fir
- Site(s): vicinity of Farley Lake, vicinity of Alpine Lake
- Relative abundance: rare
- Pollution sensitivity: Unknown
- Comments: none
- Deposition of specimen: BYU Herbarium: BRY C-31496, BRY C-32160

**Lecanora muralis** (Schreber) Rabenh.
- Growth form: Crustose (with effigurate margins)
- Substrate: rock
- Site(s): vicinity of Farley Lake, along Queen's River Trail, Middle Fork Boise River
- Relative abundance: locally common
- Pollution sensitivity: Unknown
- Comments: none
- Deposition of specimen: BYU Herbarium: BRY C-31424, BRY C-31378

**Lecanora novomexicana** (B. de Lesd.) Zahlbr.
- Growth form: Crustose (with effigurate margins)
- Substrate: rock
- Site(s): vicinity of North Alpine-Flytrip Basins, vicinity of Farley Lake
- Relative abundance: locally common
- Pollution sensitivity: Unknown
- Comments: none
- Deposition of specimen: BYU Herbarium: BRY C-31442, BRY C-32169
Lecanora polytropa (Hoffm.) Rabenh.
Growth form: Crustose (absent)
Substrate: rock, soil over rock
Site(s): vicinity of North Alpine-Flytrip Basins, vicinity of Alpine Lake, vicinity of Farley Lake, along Queen's River Trail, Middle Fork Boise River
Relative abundance: rare to locally common
Pollution sensitivity: Unknown
Comments: none
Deposition of specimen: BYU Herbarium: BRY C-31423, BRY C-31383, BRY C-31441, BRY C-31490, BRY C-32168

Lecanora pseudomellea Ryan
Growth form: Crustose (with effigurate margins)
Substrate: rock
Site(s): vicinity of North Alpine-Flytrip Basins
Relative abundance: rare
Pollution sensitivity: Unknown
Comments: none
Deposition of specimen: BYU Herbarium: BRY C-31447

Lecanora rupicola (L.) Zahlbr.
Growth form: Crustose (absent)
Substrate: rock
Site(s): vicinity of North Alpine-Flytrip Basins
Relative abundance: locally common
Pollution sensitivity: Unknown
Comments: none
Deposition of specimen: BYU Herbarium: BRY C-31449

Lecanora saligna (Shrader)
Growth form: Crustose
Substrate: conifer bark, lignum
Site(s): Middle Fork Boise River, Middle Fork Boise River
Relative abundance: rare to locally common
Pollution sensitivity: intermediately sensitive to sulfur dioxide (Wetmore 1987)
Comments: none
Deposition of specimens: BYU Herbarium: BRY C-31331, BRY C-31332

Lecanora sierrae Ryan
Growth form: Crustose (with effigurate margins)
Substrate: rock
Site(s): vicinity of North Alpine-Flytrip Basins
Relative abundance: rare
Pollution sensitivity: Unknown
Comments: none
Deposition of specimen: BYU Herbarium: BRY C-31443
Lecanora varia (Hoffm.) Ach.
Growth form: Crustose (absent)
Substrate: lignum, Douglas Fir
Site(s): along Queen's River Trail, Middle Fork Boise River, vicinity of Alpine Lake, vicinity of Farley Lake
Relative abundance: locally common to abundant
Pollution sensitivity: Unknown
Comments: none
Deposition of specimens: BYU Herbarium: BRY C-31313, BRY C-31375, BRY C-31488, BRY C-32170

Lecidea atrobrunnea (Ramond in Lam. & DC.) Schärer
Growth form: Crustose
Substrate: rock
Site(s): vicinity of Alpine Lake, vicinity of Farley Lake, vicinity of North Alpine-Flytrip Basins, along Queen's River Trail, Middle Fork Boise River
Relative abundance: locally common to abundant
Pollution sensitivity: Unknown
Comments: none
Deposition of specimen: BYU Herbarium: BRY C-31320, BRY C-31364, BRY C-31454, BRY C-31489, BRY C-32173

Lecidea tessellata Flörke
Growth form: Crustose
Substrate: rock
Site(s): vicinity of North Alpine-Flytrip Basin, vicinity of Alpine Lake, vicinity of Farley Lake, along Queen's River Trail, Middle Fork Boise River
Relative abundance: locally common
Pollution sensitivity: Unknown
Comments: none
Deposition of specimen: BYU Herbarium: BRY C-31324, BRY C-31374, BRY C-31451, BRY C-31491, BRY C-32174

Lecidea turgidula Fr.
Growth form: Crustose
Substrate: conifer bark
Site(s): vicinity of North Alpine Basin, vicinity of Farley Lake
Relative abundance: rare
Pollution sensitivity: Unknown
Comments: none
Deposition of specimen: BYU Herbarium: BRY C-31450

Lecidella euphorea (Flörke) Hertel
Growth form: Crustose
Substrate: lignum, Douglas Fir
Site(s): vicinity of North Alpine-Flytrip Basins, vicinity of Alpine Lake, vicinity of Farley Lake
Relative abundance: locally common
Pollution sensitivity: Unknown
Comments: none
Deposition of specimen: BYU Herbarium: BRY C-31455, BRY C-31492, BRY C-32176, BRY C-32177
**Lecidella stigmatica** (Ach.) Hertel & Leuck.
Growth form: Crustose
Substrate: rock
Site(s): vicinity of Alpine Lake, vicinity of Farley Lake, vicinity of North Alpine-Flytrip Basins, along Queen's River Trail
Relative abundance: rare to locally common
Pollution sensitivity: Unknown
Comments: none
Deposition of specimen: BYU Herbarium: BRY C-31325, BRY C-31432, BRY C-32175

**Lepraria neglecta** (Nyl.) Lettau
Growth form: Crustose
Substrate: soil
Site(s): vicinity of North Alpine Basin
Relative abundance: rare to locally common
Pollution sensitivity: Unknown
Comments: none
Deposition of specimens: BYU Herbarium: BRY C-31456

**Leptochilium albociliatum** (Desmaz.) M. Choisy
Growth form: Foliose
Substrate: moss over rock
Site(s): Middle Fork Boise River
Relative abundance: rare to locally common
Pollution sensitivity: sensitive to intermediate to sensitive to ozone (Ryan 1990)
Comments: none
Deposition of specimens: BYU Herbarium: BRY C-31358

**Letharia columbiana** (Nutt.) Thomson
Growth form: Fruticose
Substrate: Lodgepole Pine, lignum, Douglas Fir
Site(s): vicinity of North Alpine-Flytrip Basins, along Queen's River Trail, Middle Fork Boise River, vicinity of Alpine Lake
Relative abundance: common to locally abundant
Pollution sensitivity: intermediate to sensitive to ozone (Ryan 1990)
Comments: none
Deposition of specimens: BYU Herbarium: BRY C-31300, BRY C-31405, BRY C-31458, BRY C-31494, BRY C-32167

**Letharia vulpina** (L.) Hue
Growth form: Fruticose
Substrate: Douglas Fir, lignum
Site(s): vicinity of North Alpine-Flytrip Basins, vicinity of Alpine Lake, vicinity of Farley Lake, along Queen's River Trail, Middle Fork Boise River
Relative abundance: common to abundant
Pollution sensitivity: intermediate to sensitive to ozone (Ryan 1990)
Comments: none
Deposition of specimens: BYU Herbarium: BRY C-31301, BRY C-31333, BRY C-31356, BRY C-31457, BRY C-31493, BRY C-32166, BRY C-32178
**Melanella exasperata** (Nyl.) Essl.
Growth form: Foliolate
Substrate: lignum, Douglas Fir
Site(s): vicinity of Alpine Lake, Middle Fork Boise River, vicinity of Farley Lake
Relative abundance: rare to locally common
Pollution sensitivity: intermediately sensitive to sulfur dioxide (Ryan 1990)
Comments: none
Deposition of specimens: BYU Herbarium: BRY C-31386, BRY C-31392, BRY C-31417, BRY C-31498, BRY C-32180, BRY C-32181

**Melanella granulosa** (Lynge) Essl.
Growth form: Foliolate
Substrate: rock
Site(s): vicinity of North Alpine-Flytrip Basins, Middle Fork Boise River
Relative abundance: rare
Pollution sensitivity: Unknown
Comments: none
Deposition of specimens: BYU Herbarium: BRY C-31409, BRY C-31460

**Melanella elegantula** (Zahlbr.) Essl.
Growth form: Foliolate
Substrate: moss over rock, conifer branches
Site(s): Middle Fork Boise River, vicinity of Alpine Lake
Relative abundance: rare
Pollution sensitivity: Unknown
Comments: none
Deposition of specimens: BYU Herbarium: BRY C-31351, BRY C-31495

**Melanella exasperata** (Nyl.) Essl.
Growth form: Foliolate
Substrate: Douglas Fir, Aspen
Site(s): along Queen's River Trail
Relative abundance: rare
Pollution sensitivity: intermediately sensitive to sulfur dioxide (Ryan 1990)
Comments: none
Deposition of specimens: BYU Herbarium: BRY C-32169, BRY C-32170

**Melanella sorediata** (Ach.) Goward & Ahti
Growth form: Foliolate
Substrate: rock
Site(s): vicinity of Farley Lake
Relative abundance: rare
Pollution sensitivity: Unknown
Comments: none
Deposition of specimens: BYU Herbarium: BRY C-32179

**Melanella subolivacea** (Nyl. in Hasse) Essl.
Growth form: Foliolate
Substrate: conifer bark, lignum
Site(s): along Queen's River Trail, vicinity of Alpine Lake
Relative abundance: locally common
Pollution sensitivity: intermediately sensitive to ozone (Ryan 1990)
Comments: none
Deposition of specimens: BYU Herbarium: BRY C-31302, BRY C-31497
**Micarea assimilata** (Nyl.) Coppins
- Growth form: Crustose
- Substrate: detritus
- Site(s): Middle Fork Boise River
- Relative abundance: rare to locally common
- Pollution sensitivity: Unknown
- Comments: none
- Deposition of specimens: BYU Herbarium: BRY C-31340

**Mycobilimbia berengeriana** (Massal.) Gafellner & V. Wirth *in* V. Wirth
- Growth form: Crustose
- Substrate: detritus
- Site(s): Middle Fork Boise River
- Relative abundance: rare to locally common
- Pollution sensitivity: Unknown
- Comments: none
- Deposition of specimens: BYU Herbarium: BRY C-31346

**Nephroma parile** (Ach.) Ach.
- Growth form: Foliose
- Substrate: rock, moss over soil, Douglas Fir, moss over rock
- Site(s): Middle Fork Boise River
- Relative abundance: rare to locally common
- Pollution sensitivity: Unknown
- Comments: none
- Deposition of specimens: BYU Herbarium: BRY C-31339, BRY C-31341, BRY C-31345, BRY C-31411

**Ochrolechia androgyna** (Hoffm.) Arnold
- Growth form: Crustose
- Substrate: conifer bark, Douglas Fir
- Site(s): Middle Fork Boise River, vicinity of Farley Lake, along Queen's River Trail
- Relative abundance: rare
- Pollution sensitivity: sensitive to sulfur dioxide (Wetmore 1987)
- Comments: none
- Deposition of specimens: BYU Herbarium: BRY C-31389, BRY C-32173, BRY C-32196

**Pannaria leucophaca** (Vahl) P.Jorg.
- Growth form: Squamulose
- Substrate: soil over rock
- Site(s): Middle Fork Boise River
- Relative abundance: rare to locally common
- Pollution sensitivity: Unknown
- Comments: none
- Deposition of specimens: BYU Herbarium: BRY C-31354

**Parmelia saxatilis** (L.) Ach.
- Growth form: Foliose
- Substrate: rock
- Site(s): Middle Fork Boise River
- Relative abundance: rare to locally common
- Pollution sensitivity: intermediately sensitive to sulfur dioxide (Ryan 1990)
- Comments: none
- Deposition of specimens: BYU Herbarium: BRY C-31396
**Parmeliopsis ambiguus** (Wulfen in Jacq.) Nyl.
- Growth form: Foliose
- Substrate: Douglas Fir, lignum
- Site(s): along Queen's River Trail, Middle Fork Boise River, vicinity of North Alpine-Flytrip Basins, vicinity of Alpine Lake, vicinity of Farley Lake
- Relative abundance: locally common to abundant
- Pollution sensitivity: immediately sensitive to sulfur dioxide (Ryan 1990)
- Comments: none
- Deposition of specimens: BYU Herbarium: BRY C-31311, BRY C-31312, BRY C-31391, BRY C-31459, BRY C-31499, BRY C-32182

**Parmeliopsis hyperopta** (Ach.) Arnold
- Growth form: Foliose
- Substrate: conifer bark
- Site(s): along Queen's River Trail
- Relative abundance: rare to locally common
- Pollution sensitivity: immediately sensitive to sulfur dioxide (Ryan 1990)
- Comments: none
- Deposition of specimens: BYU Herbarium: BRY C-31307

**Peltigera aphthosa** (L.) Willd.
- Growth form: Foliose
- Substrate: soil, moss/soil over rock
- Site(s): Middle Fork Boise River, vicinity of North Alpine-Flytrip Basins
- Relative abundance: locally common
- Pollution sensitivity: Unknown
- Comments: none
- Deposition of specimens: BYU Herbarium: BRY C-31397, BRY C-31407, BRY C-31461

**Peltigera canina** (L.) Willd.
- Growth form: Foliose
- Substrate: soil, mossy soil
- Site(s): Middle Fork Boise River, vicinity of Alpine Lake, vicinity of Farley Lake, along Queen's River Trail
- Relative abundance: locally common
- Pollution sensitivity: sensitive to ozone (Ryan 1990)
- Comments: none
- Deposition of specimens: BYU Herbarium: BRY C-31399, BRY C-32149, BRY C-32172, BRY C-32184

**Peltigera malacea** (Ach.) Funck
- Growth form: Foliose
- Substrate: mossy soil, soil
- Site(s): vicinity of Alpine Lake, vicinity of Farley Lake
- Relative abundance: rare to locally common
- Pollution sensitivity: Unknown
- Comments: none
- Deposition of specimens: BYU Herbarium: BRY C-32148, BRY C-32185
**Peltigera rufescens** (Weis) Humb.
- Growth form: Foliose
- Substrate: soil
- Site(s): vicinity of North Alpine-Flytrip Basins
- Relative abundance: locally common to abundant
- Pollution sensitivity: Unknown
- Comments: none
- Deposition of specimens: BYU Herbarium: BRY C-31462

**Phaeophyscia endococcina** (Körber) Moberg
- Growth form: Foliose
- Substrate: rock
- Site(s): Middle Fork Boise River, vicinity of Farley Lake
- Relative abundance: rare to locally common
- Pollution sensitivity: Unknown
- Comments: none
- Deposition of specimens: BYU Herbarium: BRY C-31384, BRY C-32186

**Phaeophyscia orbicularis** (Necker) Moberg
- Growth form: Foliose
- Substrate: rock
- Site(s): Middle Fork Boise River, vicinity of North Alpine-Flytrip Basins
- Relative abundance: rare
- Pollution sensitivity: sensitive ozone; intermediately sensitive to sulfur dioxide; sensitive to flouride (Ryan 1990)
- Comments: none
- Deposition of specimens: BYU Herbarium: BRY C-31371, BRY C-31465

**Physcia caesia** (Hoffm.) Fürnr.
- Growth form: Foliose
- Substrate: rock
- Site(s): vicinity of North Alpine-Flytrip Basins, vicinity of Farley Lake
- Relative abundance: locally common
- Pollution sensitivity: intermediately sensitive to sulfur dioxide (Ryan 1990)
- Comments: none
- Deposition of specimens: BYU Herbarium: BRY C-31463, BRY C-32187

**Physcia dubia** (Hoffm.) Lettau
- Growth form: Foliose
- Substrate: rock, burned wood
- Site(s): along Queen's River Trail, Middle Fork Boise River, vicinity of North Alpine-Flytrip Basins, vicinity of Farley Lake
- Relative abundance: rare
- Pollution sensitivity: sensitive to intermediately sensitive to flouride (Ryan 1990)
- Comments: none
- Deposition of specimens: BYU Herbarium: BRY C-31321, BRY C-31365, BRY C-31414, BRY C-31464, BRY C-32188
Psora nipponica (Zahlbr.) G. Schneider
Growth form: Squamulose
Substrate: soil
Site(s): Middle Fork Boise River
Relative abundance: rare to locally common
Pollution sensitivity: Unknown
Comments: none
Deposition of specimens: BYU Herbarium: BRY C-31342

Psora hypnorum (Vahl) Gray
Growth form: Squamulose
Substrate: moss over soil
Site(s): along Queen's River Trail
Relative abundance: rare to locally common
Pollution sensitivity: Unknown
Comments: none
Deposition of specimens: BYU Herbarium: BRY C-31317

Rhizocarpon disporum (Naeg. ex Hepp) Müll
Growth form: Crustose
Substrate: rock
Site(s): along Queen's River Trail, Middle Fork Boise River, vicinity of North Alpine-Flytrip Basins, vicinity of Farley Lake
Relative abundance: locally common to abundant
Pollution sensitivity: Unknown
Comments: none
Deposition of specimens: BYU Herbarium: BRY C-31420, BRY C-31363, BRY C-31467, BRY C-32190

Rhizocarpon geographicum (L.) DC.
Growth form: Crustose
Substrate: rock
Site(s): along Queen's River Trail, Middle Fork Boise River, vicinity of North Alpine-Flytrip Basins, vicinity of Alpine Lake, vicinity of Farley Lake
Relative abundance: common to abundant
Pollution sensitivity: sensitive to fluoride (Ryan 1990)
Comments: none
Deposition of specimens: BYU Herbarium: BRY C-31422, BRY C-31366, BRY C-31469, BRY C-32150, BRY C-32191

Rhizocarpon simillimum (Anzi) Lettau
Growth form: Crustose
Substrate: rock
Site(s): vicinity of North Alpine-Flytrip Basins
Relative abundance: rare
Pollution sensitivity: Unknown
Comments: none
Deposition of specimens: BYU Herbarium: BRY C-31470
Physcia phaea (Tuck.) Thomson
Growth form: Foliose
Substrate: rock
Site(s): Middle Fork Boise River
Relative abundance: rare
Pollution sensitivity: Unknown
Comments: none
Deposition of specimens: BYU Herbarium: BRY C-31400

Physconia muscigena (Ach.) Poelt
Growth form: Foliose
Substrate: moss over rock, moss
Site(s): Middle Fork Boise River, vicinity of North Alpine-Flytrip Basins
Relative abundance: locally common
Pollution sensitivity: Unknown
Comments: none
Deposition of specimens: BYU Herbarium: BRY C-31360, BRY C-31466

Platismatia glauca (L.) Cubl. & C. Cubl.
Growth form: Foliose
Substrate: Douglas Fir
Site(s): vicinity of Farley Lake
Relative abundance: rare to locally common
Pollution sensitivity: intermediately sensitive to sulfur dioxide (Wetmore 1987)
Comments: none
Deposition of specimens: BYU Herbarium: BRY C-32183

Polycladium muscicola (Swartz) Gray
Growth form: Foliose
Substrate: moss over rock, rock
Site(s): along Queen's River Trail, Middle Fork Boise River
Relative abundance: rare to locally common
Pollution sensitivity: Unknown
Comments: none
Deposition of specimens: BYU Herbarium: BRY C-31319, BRY C-31398

Protoparmelia badia (Hoffm.) Hafellner
Growth form: Crustose
Substrate: rock
Site(s): vicinity of North Alpine-Flytrip Basins
Relative abundance: rare to locally common
Pollution sensitivity: Unknown
Comments: none
Deposition of specimens: BYU Herbarium: BRY C-31446

Pseudephighe pubescens (L.) M. Choisy
Growth form: Fruticose
Substrate: rock
Site(s): Middle Fork Boise River, vicinity of North Alpine-Flytrip Basins, vicinity of Farley Lake
Relative abundance: rare to locally common
Pollution sensitivity: intermediately sensitive to ozone (Ryan 1990)
Comments: none
Deposition of specimens: BYU Herbarium: BRY C-31350, BRY C-31440, BRY C-32189
**Rhizocarpon superficiale** (Schaerer) Vainio
Growth form: Crustose
Substrate: rock
Site(s): vicinity of North Alpine-Flytrip Basins
Relative abundance: rare
Pollution sensitivity: Unknown
Comments: none
Deposition of specimens: BYU Herbarium: BRY C-31468

**Rhizoplaca chrysroleuca** (Sm.) Zopf
Growth form: Foliose (umbilicate)
Substrate: rock
Site(s): vicinity of Farley Lake
Relative abundance: rare to locally common
Pollution sensitivity: sensitive to sulfur dioxide; sensitive to NO\textsubscript{x}/PAN (Ryan 1990)
Comments: none
Deposition of specimens: BYU Herbarium: BRY C-32193

**Rhizoplaca melanophthalma** (DC. in Lam. & DC.) Leuck. & Poelt
Growth form: Foliose (umbilicate)
Substrate: rock
Site(s): vicinity of North Alpine-Flytrip Basins, vicinity of Farley Lake
Relative abundance: locally common
Pollution sensitivity: sensitive to sulfur dioxide (Ryan 1990)
Comments: none
Deposition of specimens: BYU Herbarium: BRY C-31471, BRY C-32192

**Rhizoplaca peltata** (Ramond) Leuck. & Poelt
Growth form: Foliose (umbilicate)
Substrate: rock
Site(s): Middle Fork Boise River
Relative abundance: rare
Pollution sensitivity: Unknown
Comments: none
Deposition of specimens: BYU Herbarium: BRY C-31367

**Rinodina milvina** (Wahlenb. in Ach.) Th. Fr.
Growth form: Crustose
Substrate: rock
Site(s): vicinity of Farley Lake
Relative abundance: rare
Pollution sensitivity: Unknown
Comments: none
Deposition of specimens: BYU Herbarium: BRY C-32194

**Schaereria cinereorufa** (Schaerer) Th. Fr.
Growth form: Squamulose
Substrate: soil over rock
Site(s): Middle Fork Boise River
Relative abundance: rare
Pollution sensitivity: Unknown
Comments: none
Deposition of specimens: BYU Herbarium: BRY C-31344
Physcia phaea (Tuck.) Thomson
  Growth form: Foliose
  Substrate: rock
  Site(s): Middle Fork Boise River
  Relative abundance: rare
  Pollution sensitivity: Unknown
  Comments: none
  Deposition of specimens: BYU Herbarium: BRY C-31400

Physconia muscigena (Ach.) Poelt
  Growth form: Foliose
  Substrate: moss over rock, moss
  Site(s): Middle Fork Boise River, vicinity of North Alpine-Flytrip Basins
  Relative abundance: locally common
  Pollution sensitivity: Unknown
  Comments: none
  Deposition of specimens: BYU Herbarium: BRY C-31360, BRY C-31466

Platismatia glauca (L.) Culb. & C. Culb.
  Growth form: Foliose
  Substrate: Douglas Fir
  Site(s): vicinity of Farley Lake
  Relative abundance: rare to locally common
  Pollution sensitivity: intermediately sensitive to sulfur dioxide (Wetmore 1987)
  Comments: none
  Deposition of specimens: BYU Herbarium: BRY C-32183

Polychidium muscicola (Swartz) Gray
  Growth form: Foliose
  Substrate: moss over rock, rock
  Site(s): along Queen's River Trail, Middle Fork Boise River
  Relative abundance: rare to locally common
  Pollution sensitivity: Unknown
  Comments: none
  Deposition of specimens: BYU Herbarium: BRY C-31319, BRY C-31398

Protoparmelia badia (Hoffm.) Hafellner
  Growth form: Crustose
  Substrate: rock
  Site(s): vicinity of North Alpine-Flytrip Basins
  Relative abundance: rare to locally common
  Pollution sensitivity: Unknown
  Comments: none
  Deposition of specimens: BYU Herbarium: BRY C-31446

Pseudopebea pubescens (L.) M. Choisy
  Growth form: Fruticose
  Substrate: rock
  Site(s): Middle Fork Boise River, vicinity of North Alpine-Flytrip Basins, vicinity of Farley Lake
  Relative abundance: rare to locally common
  Pollution sensitivity: intermediately sensitive to ozone (Ryan 1990)
  Comments: none
  Deposition of specimens: BYU Herbarium: BRY C-31350, BRY C-31440, BRY C-32189
Psora nipponica (Zahlbr.) G. Schneider
- Growth form: Squamulose
- Substrate: soil
- Site(s): Middle Fork Boise River
- Relative abundance: rare to locally common
- Pollution sensitivity: Unknown
- Comments: none
- Deposition of specimens: BYU Herbarium: BRY C-31342

Psoroma hypnorum (Vahl) Gray
- Growth form: Squamulose
- Substrate: moss over soil
- Site(s): along Queen's River Trail
- Relative abundance: rare to locally common
- Pollution sensitivity: Unknown
- Comments: none
- Deposition of specimens: BYU Herbarium: BRY C-31317

Rhizocarpon disporum (Naeg. ex Hepp) Müll
- Growth form: Crustose
- Substrate: rock
- Site(s): along Queen's River Trail, Middle Fork Boise River, vicinity of North Alpine-Flytrip Basins, vicinity of Farley Lake
- Relative abundance: locally common to abundant
- Pollution sensitivity: Unknown
- Comments: none
- Deposition of specimens: BYU Herbarium: BRY C-31420, BRY C-31363, BRY C-31467, BRY C-32190

Rhizocarpon geographicum (L.) DC.
- Growth form: Crustose
- Substrate: rock
- Site(s): along Queen's River Trail, Middle Fork Boise River, vicinity of North Alpine-Flytrip Basins, vicinity of Alpine Lake, vicinity of Farley Lake
- Relative abundance: common to abundant
- Pollution sensitivity: sensitive to flouride (Ryan 1990)
- Comments: none
- Deposition of specimens: BYU Herbarium: BRY C-31422, BRY C-31366, BRY C-31469, BRY C-32150, BRY C-32191

Rhizocarpon simillimum (Anzi) Lettau
- Growth form: Crustose
- Substrate: rock
- Site(s): vicinity of North Alpine-Flytrip Basins
- Relative abundance: rare
- Pollution sensitivity: Unknown
- Comments: none
- Deposition of specimens: BYU Herbarium: BRY C-31470
Rhizocarpon superficiale (Schaerer) Vainio
Growth form: Crustose
Substrate: rock
Site(s): vicinity of North Alpine-Flytrip Basins
Relative abundance: rare
Pollution sensitivity: Unknown
Comments: none
Deposition of specimens: BYU Herbarium: BRY C-31468

Rhizoplaca chrysoleuca (Sm.) Zopf
Growth form: Foliose (umbilicate)
Substrate: rock
Site(s): vicinity of Farley Lake
Relative abundance: rare to locally common
Pollution sensitivity: sensitive to sulfur dioxide; sensitive to NOx/PAN (Ryan 1990)
Comments: none
Deposition of specimens: BYU Herbarium: BRY C-32193

Rhizoplaca melanophtalma (DC. in Lam. & DC.) Leuck. & Poelt
Growth form: Foliose (umbilicate)
Substrate: rock
Site(s): vicinity of North Alpine-Flytrip Basins, vicinity of Farley Lake
Relative abundance: locally common
Pollution sensitivity: sensitive to sulfur dioxide (Ryan 1990)
Comments: none
Deposition of specimens: BYU Herbarium: BRY C-31471, BRY C-32192

Rhizoplaca pelitata (Ramond) Leuck. & Poelt
Growth form: Foliose (umbilicate)
Substrate: rock
Site(s): Middle Fork Boise River
Relative abundance: rare
Pollution sensitivity: Unknown
Comments: none
Deposition of specimens: BYU Herbarium: BRY C-31367

Rinodina milvina (Wahlenb. in Ach.) Th. Fr.
Growth form: Crustose
Substrate: rock
Site(s): vicinity of Farley Lake
Relative abundance: rare
Pollution sensitivity: Unknown
Comments: none
Deposition of specimens: BYU Herbarium: BRY C-32194

Schaereria cinereorufa (Schaerer) Th. Fr.
Growth form: Squamate
Substrate: soil over rock
Site(s): Middle Fork Boise River
Relative abundance: rare
Pollution sensitivity: Unknown
Comments: none
Deposition of specimens: BYU Herbarium: BRY C-31344
**Sporostatia testudinea** (Ach.) Massal.
Growth form: Crustose
Substrate: rock
Site(s): vicinity of North Alpine-Flytrip Basins
Relative abundance: locally common
Pollution sensitivity: Unknown
Comments: none
Deposition of specimens: BYU Herbarium: BRY C-31472

**Staurotheca drummondii** (Tuck.) Tuck.
Growth form: Crustose
Substrate: rock
Site(s): vicinity of North Alpine-Flytrip Basins
Relative abundance: rare
Pollution sensitivity: Unknown
Comments: none
Deposition of specimens: BYU Herbarium: BRY C-31473

**Tephromela armeniaca** (DC.) Hertel
Growth form: Crustose
Substrate: rock
Site(s): vicinity of North Alpine-Flytrip Basins
Relative abundance: rare
Pollution sensitivity: Unknown
Comments: none
Deposition of specimens: BYU Herbarium: BRY C-31452

**Tracheliopsis granulosa** (Hoffm.) Lumbsch.
Growth form: Crustose
Substrate: lignum, humic soil
Site(s): along Queen's River Trail, Middle Fork Boise River
Relative abundance: locally common to abundant
Pollution sensitivity: Unknown
Comments: none
Deposition of specimens: BYU Herbarium: BRY C-31330, BRY C-31418

**Tuckermannopsis canadensis** (Räisänen) Hale
Growth form: Foliose
Substrate: Lodgepole Pine
Site(s): Middle Fork Boise River
Relative abundance: locally common
Pollution sensitivity: sensitive to ozone (Ryan 1990)
Comments: none
Deposition of specimens: BYU Herbarium: BRY C-31334, BRY C-31402

**Tuckermannopsis chlorophylla** (Willd. in Humb.) Hale
Growth form: Foliose
Substrate: conifer bark
Site(s): Middle Fork Boise River
Relative abundance: rare to locally common
Pollution sensitivity: sensitive to sulfur dioxide (Ryan 1990)
Comments: none
Deposition of specimens: BYU Herbarium: BRY C-31387
Tuckermannopsis merrillii (Du Rietz) Hale
Growth form: Fruticose
Substrate: Lodgepole Pine
Site(s): Middle Fork Boise River, along Queen’s River Trail
Relative abundance: rare
Pollution sensitivity: sensitive to intermediately sensitive to ozone (Ryan 1990)
Comments: none
Deposition of specimens: BYU Herbarium: BRY C-31388, BRY C-31406, BRY C-32174

Tuckermannopsis platyphylla (Tuck.) Hale
Growth form: Foliose
Substrate: Douglas Fir
Site(s): along Middle Fork of Boise River, along Queen’s River Trail
Relative abundance: rare to locally common
Pollution sensitivity: Unknown
Comments: none
Deposition of specimens: BYU Herbarium: BRY C-32154, BRY C-32160

Umbilicaria americana sp. nov.
Growth form: Foliose (umbilicate)
Substrate: rock
Site(s): Middle Fork Boise River
Relative abundance: locally common
Pollution sensitivity: Unknown
Comments: none
Deposition of specimens: BYU Herbarium: BRY C-31359

Umbilicaria hyperborea (Ach.) Hoffm.
Growth form: Foliose (umbilicate)
Substrate: rock
Site(s): along Queen’s River Trail, Middle Fork Boise River, vicinity of North Alpine-Flytrip Basins, vicinity of Farley Lake
Relative abundance: locally common to abundant
Pollution sensitivity: Unknown
Comments: none
Deposition of specimens: BYU Herbarium: BRY C-31315, BRY C-31338, BRY C-31348, BRY C-31415, BRY C-31476, BRY C-32197

Umbilicaria krascheninnikovii (Savicz) Zalibr.
Growth form: Foliose (umbilicate)
Substrate: rock
Site(s): vicinity of North Alpine-Flytrips Basins, vicinity of Farley Lake
Relative abundance: rare to locally common
Pollution sensitivity: Unknown
Comments: none
Deposition of specimens: BYU Herbarium: BRY C-31475, BRY C-32198
**Umbilicaria torrefacta** (Lightf.) Scharader
- **Growth form:** Foliose (umbilicate)
- **Substrate:** rock
- **Site(s):** Middle Fork Boise River
- **Relative abundance:** rare
- **Pollution sensitivity:** Unknown
- **Comments:** none
- **Deposition of specimens:** BYU Herbarium: BRY C-31349

**Umbilicaria vellex** (L.) Ach.
- **Growth form:** Foliose (umbilicate)
- **Substrate:** rock
- **Site(s):** vicinity of North Alpine-Flytrip Basins, vicinity of Alpine Lake
- **Relative abundance:** rare to locally abundant
- **Pollution sensitivity:** Unknown
- **Comments:** none
- **Deposition of specimens:** BYU Herbarium: BRY C-31438, BRY C-32151

**Umbilicaria virginis** Schaerer
- **Growth form:** Foliose (umbilicate)
- **Substrate:** rock
- **Site(s):** vicinity of North Alpine-Flytrip Basins
- **Relative abundance:** locally common to abundant
- **Pollution sensitivity:** Unknown
- **Comments:** none
- **Deposition of specimens:** BYU Herbarium: BRY C-31474

**Usnea birta** (L.) Weber ex Wigg.
- **Growth form:** Fruticose
- **Substrate:** conifer bark
- **Site(s):** Middle Fork Boise River
- **Relative abundance:** rare
- **Pollution sensitivity:** sensitive to ozone (Ryan 1990)
- **Comments:** none
- **Deposition of specimens:** BYU Herbarium: BRY C-31369

**Usnea subfloridana** Stirton
- **Growth form:** Fruticose
- **Substrate:** conifer bark
- **Site(s):** Middle Fork Boise River
- **Relative abundance:** rare to locally common
- **Pollution sensitivity:** sensitive to intermediateley sensitive to sulfur dioxide (Ryan 1990)
- **Comments:** none
- **Deposition of specimens:** BYU Herbarium: BRY C-31368

**Xanthoparmelia coloradoensis** (Gyelnik) Hale
- **Growth form:** Foliose
- **Substrate:** rock, detritus
- **Site(s):** vicinity of North Alpine-Flytrip Basins
- **Relative abundance:** rare
- **Pollution sensitivity:** Unknown
- **Comments:** none
- **Deposition of specimens:** BYU Herbarium: BRY C-31477, BRY C-31478
**Xanthoparmelia cumberlandia** (Gyelnik) Hale  
Growth form: Foliose  
Substrate: rock  
Site(s): Middle Fork Boise River  
Relative abundance: rare to locally common  
Pollution sensitivity: sensitive to sulfur diox ide (Ryan 1990)  
Comments: none  
Deposition of specimens: BYU Herbarium: BRY C-31361

**Xanthoria candelaria** (L.) Th. Fr.  
Growth form: Foliose  
Substrate: Douglas Fir, Aspen  
Site(s): vicinity of Farley Lake, along Queen's River Trail  
Relative abundance: rare  
Pollution sensitivity: intermittently sensitive to sulfur dioxide (Ryan 1990)  
Comments: none  
Deposition of specimens: BYU Herbarium: BRY C-32159, BRY C-32171, BRY C-32199

**Xanthoria elegans** (Link.) Th. Fr.  
Growth form: Foliose  
Substrate: rock  
Site(s): vicinity of North Alpine-Flytrip Basins  
Relative abundance: locally common  
Pollution sensitivity: Unknown  
Comments: none  
Deposition of specimens: BYU Herbarium: BRY C-31479

**Xanthoria fallax** (Hepp in Arnold)  
Growth form: Foliose  
Substrate: lignum  
Site(s): Middle Fork Boise River  
Relative abundance: locally common  
Pollution sensitivity: intermittently sensitive to sulfur dioxide; sensitive to NOx/PAN (Ryan 1990)  
Comments: none  
Deposition of specimens: BYU Herbarium: BRY C-31337

**Observations:**

1. Collections made during the summers of 1988 and 1989 included a diverse group of lichen species. The flora includes a total of 118 species in 54 genera. All growth forms in the wilderness area are well represented; however the flora is dominated by crustose species (44%, 52 species), followed by foliose species (37%, 44 species). Fruticose lichens represent 9% (10 species) while squamulose species comprise 10% (12 species) of the flora. This growth form pattern is typical of the Intermountain Area. Comparing favorably with other Intermountain Area lichen floras which are typically dominated by crustose species (48% in the Bridger Wilderness Area (Wyoming), and 50% in the High Uintas Wilderness Area (Utah); with foliose species representing only 28% and 29% of these floras respectively. The higher percentage of foliose species in the Sawtooth Wilderness Area (36%) is largely due to a Pacific Northwest influence on the two reference sites located on the west side of the wilderness area (reference site #5 (along the Middle Fork of the Boise River) and reference site #6 (along Queen’s River Trail)).
2. During this study, lichens were collected from 5 basic substrates: rocks, lignum/bark, moss/detritus, soil, and lichen thalli. A total of 55 species (46% of the flora) were collected from rock substrates. Bark and lignum substrates were second in importance accounting for 37 species (31% of the flora). Fourteen species (12% of the flora) were collected from moss or detritus, with 11 species (10% of the flora) from the soil and one species (<1%) growing over other lichen thalli. This substrate pattern is also more typical of Intermountain Area lichen communities, where various rock substrates support abundant lichen growth. The influence of regional weather patterns, along with the occurrence of well-developed, suitable microhabitats and the dispersal of asexual/sexual propagules by prevailing winds has effectively accommodated the movement of some Pacific Northwest, corticolous lichen species into the two reference sites on the west side of the wilderness.

3. High species diversity as well as an abundance of all basic growth forms (especially the more pollution sensitive foliose and fruticose species) indicates that the lichen communities in the Sawtooth Wilderness Area are healthy and have not been impacted by air pollution.

4. The abundance of sensitive indicator species at all reference sites {vicinity of Alpine Lake (11 spp.), vicinity of Fairley Lake (17 spp.), vicinity of North Alpine-Flytrip basins (10 spp.), Middle Fork of the Boise River (23 spp.), and Queen's River (22 spp.)} further documents that the lichen flora in the wilderness area is healthy and unimpacted by air pollution. The higher number of sensitive indicator species from the western side of the wilderness (23 and 22 spp. respectively) again reflects the Pacific Northwest influence, manifested specifically in terms of higher numbers of fruticose and foliose species.

5. The general absence of necrotic and/or bleached thalli also suggests that the lichen flora is unimpacted.

6. 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). Thallus concentrations of all potential pollutant elements are well within background levels* (Figure 2). *Note: as indicated in my earlier report (1989) the high sulfur values for Dermatocarpon miniatum are most likely due to the fact that this species seems to preferentially occupy substrates that are inherently high in sulfur. Thus, the high sulfur values for this species reflects substrate contamination, and not air pollution impact. This conclusion is further substantiated by the much lower sulfur values obtained for the other sensitive indicator species. Discrepancy between the 1988 values for lead and copper and the 1993 values for these same elements is likely due to differences in detectability limits of the two analysis techniques. The 1988 and 1989 samples are currently being reevaluated using PIXE technology. This should clear up the discrepancies, plus give us better resolution with the 1988 and 1989 material along with baseline data for the other 17 potential pollutant elements.

**Recommendations:**

1. Eventually, 2 additional reference sites should be established along the northern boundary of the wilderness area (possibly, accessing the wilderness from Stanley Lake, and Grandjean trailheads). One additional site should also be established along the western boundary of the wilderness (possibly, along the North Fork of the Boise River from Graham Trailhead). These additional sites will provide a more complete bimonitoring network as well as further information about the lichen flora and additional baseline information about the status of sensitive indicator species. Reevaluation of the sensitive indicator species from the two 1989 reference sites (sites 5 and 6) should be performed within the next one to two years.
<table>
<thead>
<tr>
<th>Species and Collection Site</th>
<th>S%</th>
<th>Cl</th>
<th>K%</th>
<th>Ca%</th>
<th>Ti</th>
<th>V</th>
<th>Cr</th>
<th>Ni</th>
<th>Cu 1998</th>
<th>Cu 1993</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Dermatocarpon minutum</em>, Farley Lake, Sample #193</td>
<td>0.476</td>
<td>0.24</td>
<td>360</td>
<td>0.6</td>
<td>0.1</td>
<td>210</td>
<td>2</td>
<td>5</td>
<td>4</td>
<td>7.7</td>
</tr>
<tr>
<td><em>Umbilicaria vellea</em>, Farley Lake, Sample #194</td>
<td>n.d.</td>
<td>0.146</td>
<td>300</td>
<td>5.2</td>
<td>0.54</td>
<td>89</td>
<td>3</td>
<td>n.d.</td>
<td>n.d.</td>
<td>n.d.</td>
</tr>
<tr>
<td><em>Letharia vulpina</em>, Farley Lake, Sample #195</td>
<td>0.179</td>
<td>0.062</td>
<td>250</td>
<td>2.2</td>
<td>5.6</td>
<td>60</td>
<td>n.d.</td>
<td>n.d.</td>
<td>n.d.</td>
<td>2</td>
</tr>
<tr>
<td><em>Dermatocarpon minutum</em>, Alpine Lake, Sample #196</td>
<td>0.276</td>
<td>0.19</td>
<td>290</td>
<td>6.1</td>
<td>0.93</td>
<td>103</td>
<td>n.d.</td>
<td>n.d.</td>
<td>n.d.</td>
<td>21.3</td>
</tr>
<tr>
<td><em>Letharia vulpina</em>, Alpine Lake, Sample #197</td>
<td>0.118</td>
<td>0.052</td>
<td>230</td>
<td>2.8</td>
<td>5.7</td>
<td>35</td>
<td>n.d.</td>
<td>n.d.</td>
<td>n.d.</td>
<td>4.8</td>
</tr>
<tr>
<td><em>Umbilicaria vellea</em>, Alpine Lake, Sample #198</td>
<td>n.d.</td>
<td>0.1</td>
<td>320</td>
<td>5.5</td>
<td>0.9</td>
<td>120</td>
<td>n.d.</td>
<td>n.d.</td>
<td>3</td>
<td>n.d.</td>
</tr>
<tr>
<td>Species and Collection Site</td>
<td>Zn</td>
<td>1988</td>
<td>Pb</td>
<td>1993</td>
<td>Mn</td>
<td>Fe</td>
<td>Co</td>
<td>As</td>
<td>Se</td>
<td>Br</td>
</tr>
<tr>
<td>------------------------------------------</td>
<td>-----</td>
<td>------</td>
<td>-----</td>
<td>------</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td><em>Dermatocarpon miniatum</em>, Farley Lake, Sample #193</td>
<td>66</td>
<td>102.5</td>
<td>10</td>
<td>200</td>
<td>2200</td>
<td>n.d.</td>
<td>n.d.</td>
<td>0.7</td>
<td>33</td>
<td>23</td>
</tr>
<tr>
<td><em>Umbilicaria vellea</em>, Farley Lake, Sample #194</td>
<td>109</td>
<td>n.d.</td>
<td>7</td>
<td>29</td>
<td>830</td>
<td>n.d.</td>
<td>1.68</td>
<td>n.d.</td>
<td>21</td>
<td>24</td>
</tr>
<tr>
<td><em>Letharia vulpina</em>, Farley Lake, Sample #195</td>
<td>23</td>
<td>10.2</td>
<td>8</td>
<td>97</td>
<td>230</td>
<td>n.d.</td>
<td>1.1</td>
<td>n.d.</td>
<td>9</td>
<td>4</td>
</tr>
<tr>
<td><em>Dermatocarpon miniatum</em>, Alpine Lake, Sample #196</td>
<td>25</td>
<td>10.2</td>
<td>4.7</td>
<td>57</td>
<td>920</td>
<td>n.d.</td>
<td>1</td>
<td>n.d.</td>
<td>16</td>
<td>10.6</td>
</tr>
<tr>
<td><em>Letharia vulpina</em>, Alpine Lake, Sample #197</td>
<td>39</td>
<td>18.1</td>
<td>n.d.</td>
<td>190</td>
<td>190</td>
<td>1</td>
<td>1.5</td>
<td>n.d.</td>
<td>11</td>
<td>4</td>
</tr>
<tr>
<td><em>Umbilicaria vellea</em>, Alpine Lake, Sample #198</td>
<td>250</td>
<td>n.d.</td>
<td>4</td>
<td>56</td>
<td>1300</td>
<td>n.d.</td>
<td>2.2</td>
<td>n.d.</td>
<td>18</td>
<td>21</td>
</tr>
</tbody>
</table>
Fig. 2  Lichen Biomonitoring Program and Baseline

Elemental Analysis Data
(background and elevated pollutant levels)
Fig. 2 cont. Lichen Biomonitoring Program and Baseline

Elemental Analysis Data
(background and elevated pollutant levels)
Fig. 2 cont. Lichen Biomonitoring Program and Baseline

Elemental Analysis Data
(background and elevated pollutant levels)
2. Generally, re-evaluation of sensitive indicator species should be performed every 5 to 8 years, depending on significant changes in either local or regional air pollution patterns. The development of new air pollution sources in close proximity to the wilderness area would also be a significant factor in determining the timing of followup surveys.

3. Re-evaluation of the lichen flora at existing reference sites is generally unnecessary, unless sensitive indicator species begin to show either significantly higher levels of pollutant elements or substantial changes in relative abundance.

BIBLIOGRAPHY


