

FINAL REPORT SUBMITTED TO
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NORTHERN REGION
U.S. DEPARTMENT OF AGRICULTURE
U.S. FOREST SERVICE

COPY

REGARDING:

ESTABLISHMENT OF A LICHEN BIOMONITORING PROGRAM
AND AIR QUALITY BASELINE IN THE ANACONDA-PINTLER
WILDERNESS AREA AND ADJACENT AREAS WEST OF THE
ANACONDA COPPER SMELTER

PREPARED & SUBMITTED

BY

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INTRODUCTION

PROJECT OBJECTIVES:

1. Identify 10 reference sites along a transect across the wilderness area and adjacent areas west of the Anaconda Copper Smelter.
2. Collect, curate, and identify lichen species from various habitats and substrates at each reference site.
3. Identify 3-5 pollution-sensitive lichen species at each reference site. Collect enough tissue of 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.
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.
5. Prepare and submit a draft report by 31 May 1993.
6. Prepare and submit final report details by 31 December 1993.

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 analyses 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 ANACONDA-PINTLER WILDERNESS AREA:

The Anaconda-Pintler Wilderness area is part of the Anaconda-Pintler wildland complex. The complex includes 367,745 acres, with 157,874 acres actually comprising the Anaconda-Pintler Wilderness Area. The continental divide runs the length of the wilderness with the wilderness defining the eastern and southern boundaries of the Sapphire block. Most of the Anaconda Range, and portions of the Pintlar and Sapphire mountain ranges fall within the boundaries of the wilderness. The mountains of the wilderness consist mainly of tightly folded sedimentary formations of all ages from Precambrian through Cretaceous. Over time these formations have been pushed east along several major thrust faults to their present location. Large masses of granitic magma intruded all three ranges, and crystalized to form massive intrusions. Most of the granitic intrusions lie along the thrust faults; however, since the faults have not broken the granite it seems logical that the faults have not moved since the magma crystalized. The mountainous core of the wilderness has been heavily glaciated as evidenced by the many cirques containing alpine lakes, the U-shaped valleys covered by conifer forests, and the extensive and abundant glacial moraines.

The major vascular plant communities in the wilderness include alpine tundra and krummholz in the higher elevations, subalpine meadows around glacial lakes, and extensive coniferous forests downslope, including remnants of old-growth forest in the lower valleys. Riparian communities are well developed along the many streams which drain the upper reaches of the wilderness.

LICHEN BIOMONITORING REFERENCE SITES IN THE ANACONDA-PINTLER WILDERNESS AREA:

A total of 10 reference sites were established either in the wilderness area proper, or on adjacent Forest Service land, or on private property (figures 1 & 2). More specifically, reference sites were established: 1) along the East Fork of the Bitterroot River (25 July 1992); 2) along McCart Trail (25 July 1992); 3) along Pintler Creek beginning at trailhead #37 (27 July 1992); 4) in the Mt Haggin Wildlife Management Area, along Forest Service road #2483 (28 July 1992); 5) at Ten Mile Creek, along Forest Service road #2483 (28 July 1992); 6) in the Mt. Haggin Wildlife Management Area, at Cabbage Gulch 3 miles south of SR #1 on SR #274 (28 July 1992); 7) at a basalt dike above SR #274, 7.2 miles west of SR #1, on private property (28 July 1992); 8) along the trail to Fourmile Basin Lakes (29 July 1992); 9) Goat Flats (30 July 1992); and 10) along the Middle Fork of Rock Creek, beginning at trailhead #9, along trail #28 (31 July 1992). A transect of reference sites (consisting of sites 4-10) was established in the eastern portion of the wilderness as well as on adjacent, non-wilderness Forest Service land east of the wilderness area. Data from this transect will be used to assess the impact of the Anaconda copper Smelter on lichen communities; and as a baseline for documenting recovery of lichen communities. Appendix A contains a list of the pollution sensitive indicator species by reference site.

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 piece 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 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 Plants in Provo, Utah. A second set of voucher specimens will be sent to any herbarium designated by the Forest Service.

COLLECTION OF LICHEN THALLI FOR LABORATORY ANALYSES:

After careful consideration of species abundance, substrate, growth form, documented/suspected pollution sensitivity and general distribution patterns of the lichens at each reference site, one species was designated as the sensitive, indicator species and used for all laboratory chemical analyses.

At each reference site sufficient material of at least one sensitive, indicator species was collected for laboratory analyses (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 Cryptogams. Excess material is permanently stored in Hubco cloth bags in the elemental analysis collection at the BYU Herbarium for 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 samples. Clean, two gram samples of 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 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 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 AND RECOMMENDATIONS

LICHEN MATERIAL COLLECTED FOR ELEMENTAL ANALYSES:

A total of 10 samples including 4 species from 4 substrates were collected for elemental analyses. Analyses of one species from each reference site were performed using Proton Induced X-Ray Emission (PIXE) technology. 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 indicates the bag number). All specimens are stored in Hubco cloth bags in the elemental analysis collection at the Herbarium of Nonvascular Cryptograms at Brigham Young University.

<u>Sample#</u>	<u>Taxa</u>	<u>Substrate</u>	<u>Collection Site</u>
20-162	<i>Letharia vulpina</i>	Bark	McCart Trail
20-163	<i>Letharia vulpina</i>	Bark	E. Fk Bitterroot River
20-164	<i>Letharia vulpina</i>	Lignum	Pintler Creek
20-165	<i>Umbilicaria vellea</i>	Rock	Pintler Creek
21-166	<i>Rhizoplaca</i>		
	<i>melanophthalma</i>	Rock	7 miles East of smelter
21-167	<i>Letharia vulpina</i>	Bark	Fourmile Basin
21-168	<i>Rhizoplaca</i>		
	<i>melanophthalma</i>	Rock	Fourmile Basin
21-169	<i>Cetraria nivalis</i>	Soil	Goat Flat
21- 170	<i>Letharia vulpina</i>	Bark	Tr. to Goat Flat
21-171	<i>Letharia vulpina</i>	Lignum	Middle Fk. Rock Ck.

Elemental analyses have been performed for the following samples:

20-162, 20-163, 20-164, 20-165, 21-166, 21-167, 21-168,
21-170, 21-171

**CHECKLIST OF LICHEN SPECIES FROM SELECTED SITES IN THE
ANACONDA-PINTLER WILDERNESS AREA AND ADJACENT
AREAS WEST OF THE ANACONDA COPPER SMELTER,
MONTANA**

Acarospora chlorophana (Wahlenb. ex Ach.) Massal.

Growth form: Crustose with effigurate margins

Substrate: Rock

Site(s): Goat Flat, Basalt dike (along State Road #274)

Relative abundance: Rare to locally common

Pollution sensitivity: Sensitive to sulfur dioxide (Ryan 1990)

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22993,
BRY C-23789

Acarospora fuscata (Nyl.) Arnold

Growth form: Crustose

Substrate: Rock

Site(s): McCart Lookout Trail, Pintler Creek Trailhead, Goat Flat,
Vicinity of Fourmile Basin Lakes, Basalt dike (along State
Road #274)

Relative abundance: Rare to locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22965
BRY C-22898, BRY C-23062, BRY C-23612, BRY C-23790

Alectoria imshaugii Brodo & D. Hawksw.

Growth form: Fruticose

Substrate: Lignum, conifer bark

Site(s): East Fork Bitterroot River Trail, Pintler Creek Trailhead,
Middle Fork of Rock Creek

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22818
BRY C-22899, BRY C-23080, BRY C-23081

Alectoria sarmentosa (Ach.) Ach.

Growth form: Fruticose

Substrate: Lignum, Spruce, conifer bark, *Populus tremuloides*

Site(s): East Fork Bitterroot River Trail, Pintler Creek Trailhead,

Middle Fork of Rock Creek, Mt. Haggin Wildlife

Management Area

Relative abundance: Rare to locally common

Pollution sensitivity: Sensitive to ozone (Ryan 1990)

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22819

BRY C-22900, BRY C-22901, BRY C-23082, BRY C-23083,

BRY C-23084, BRY C-23803, BRY C-23809

Arthonia glebosa Tuck.

Growth form: Crustose

Substrate: Soil

Site(s): Goat Flat

Relative abundance: Locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22994

Aspicilia aquatica Körber

Growth form: Crustose

Substrate: Rock in stream

Site(s): Pintler Creek Trailhead

Relative abundance: Locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22902

Aspicilia calcarea (L.) Mudd

Growth form: Crustose

Substrate: Rock

Site(s): McCart Lookout Trail

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22866

Aspicilia cinerea (L.) Körber

Growth form: Crustose

Substrate: Rock

Site(s): Pintler Creek Trailhead, Vicinity of Fourmile Basin
Lakes

Relative abundance: Rare to locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22903,
BRY C-23613

Aspicilia desertorum (Krempelh.) Mereschk.

Growth form: Crustose

Substrate: Rock

Site(s): Vicinity of Fourmile Basin Lakes

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-23614

Aspicilia reptans (Looman) Wetm.

Growth form: Fruticose (vagrant)

Substrate: Soil

Site(s): Goat Flat

Relative abundance: Rare to locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22995

Bellemerea alpina (Sommerf.) Clauz. & Roux

Growth form: Crustose

Substrate: Rock

Site(s): East Fork Bitterroot River Trail, Pintler Creek Trailhead,
Vicinity of Fourmile Basin Lakes

Relative abundance: Common to abundant

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22820,
BRY C-23615, BRY C-22904

Bellemerea cinereorufescens (Ach.) Clauz. & Roux

Growth form: Crustose

Substrate: Rock

Site(s): McCart Lookout Trail, Pintler Creek Trailhead,
Vicinity of Fourmile Basin Lakes

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22867
BRY C-22905, BRY C-23616

Biatora vernalis (L.) Fr.

Growth form: Crustose

Substrate: Detritus, lignum

Site(s): Goat Flat, Along U.S.F.S. Road #2483, Mt. Haggin
Wildlife Management Area

Relative abundance: Rare to locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22996,
BRY C-23797, BRY C-23804

Bryoria abbreviata (Müll. Arg.) Brodo & DD. Hawksw.

Growth form: Fruticose

Substrate: Conifer bark

Site(s): McCart Lookout Trail, Pintler Creek Trailhead, Middle
Fork of Rock Creek

Relative abundance: Rare to locally common

Pollution sensitivity: Sensitive to ozone (Ryan 1990)

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22868
BRY C-22906, BRY C-22907, BRY C-23085, BRY C-23086,
BRY C-23087

Bryoria fremontii (Tuck.) Brodo & D. Hawksw.

Growth form: Fruticose

Substrate: Conifer bark, Doug Fir

Site(s): McCart Lookout Trail, Pintler Creek Trailhead, Middle
Fork of Rock Creek, Vicinity of Fourmile Basin Lakes

Relative abundance: Rare to locally common

Pollution sensitivity: Sensitive to ozone (Ryan 1990)

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22869

BRY C-22908, BRY C-22909, BRY C-22910, BRY C-23088,
BRY C-23089, BRY C-23635

Bryoria fuscescens (Gyeln.) Brodo & Hawksw.

Growth form: Fruticose

Substrate: Lignum, conifer bark

Site(s): Pintler Creek Trailhead, Middle Fork of Rock Creek

Relative abundance: Locally common

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

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22911,

BRY C-23090, BRY C-23091, BRY C-23092

Caloplaca cerina (Ehrh. ex Hedwig) Th. Fr.

Growth form: Crustose

Substrate: Polypore growing on Quaking Aspen trunk

Site(s): Pintler Creek Trailhead

Relative abundance: Rare

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

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22912

Caloplaca cladodes (Tuck.) Zahlbr.

Growth form: Sub-fruticose

Substrate: Rock

Site(s): Goat Flat, Vicinity of Fourmile Basin Lakes

Relative abundance: Locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22997,

BRY C-23636

Caloplaca epithallina Nyne

Growth form: Crustose, obsolete
Substrate: Epiphytic on crustose, saxicolous lichens
Site(s): Goat Flat, Vicinity of Fourmile Basin Lakes
Relative abundance: Rare to locally common
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium: BRY C-23063,
BRY C-23617

Caloplaca fraudans (Th. Fr.) H. Olivier

Growth form: Crustose
Substrate: Rock, polypore growing on Aspen trunk
Site(s): McCart Lookout Trail, Pintler Creek Trailhead
Relative abundance: Rare
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium: BRY C-22870
BRY C-22913

Caloplaca jungermanniae (Vahl) Th. Fr.

Growth form: Crustose
Substrate: Detritus, moss
Site(s): Goat Flat, Vicinity of Fourmile Basin Lakes
Relative abundance: Rare to locally common
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium: BRY C-22998,
BRY C-23637

Caloplaca livida (Hepp) Jatta

Growth form: Crustose
Substrate: Detritus, moss
Site(s): McCart Lookout Trail, Goat Flat
Relative abundance: Rare
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium: BRY C-22871
BRY C-22999

Caloplaca stillicidiorum (Vahl) Lynge

Growth form: Crustose, obsolete

Substrate: Detritus

Site(s): Goat Flat, Vicinity of Fourmile Basin Lakes

Relative abundance: Locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-23016,
BRY C-23638

Caloplaca tirolensis Zahlbr.

Growth form: Crustose, obsolete

Substrate: Detritus

Site(s): Goat Flat

Relative abundance: Rare to locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-23017

Candelariella terrigena Räsänen

Growth form: Crustose with effigurate margins

Substrate: Soil

Site(s): Goat Flat

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-23018

Candelariella xanthostigma (Ach.) Lettau

Growth form: Crustose

Substrate: Lignum

Site(s): East Fork Bitterroot River Trail, McCart Lookout Trail

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22821,
BRY C-22872

Catapyrenium cinereum (Pers.) Körber

Growth form: Squamulose

Substrate: Soil

Site(s): Goat Flat

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-23019

Catapyrenium lachneum (Ach.) R. Sant.

Growth form: Squamulose

Substrate: Soil

Site(s): Goat Flat

Relative abundance: Rare to locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-23020

Cetraria ericetorum Opiz

Growth form: Foliose

Substrate: Soil (vagrant)

Site(s): Goat Flat

Relative abundance: Locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C- 23021

Cetraria islandica (L.) Ach.

Growth form: Foliose

Substrate: Soil (vagrant)

Site(s): Goat Flat

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-23022

Cetraria nivalis (L.) Ach.

Growth form: Foliose

Substrate: Soil

Site(s): Goat Flat

Relative abundance: Locally common to abundant

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-23023

Cladonia chlorophaea (Flörke *ex* Sommerf.) Sprengel

Growth form: Squamulose with podetia

Substrate: Decomposing wood, humic soil, lignum, soil

Site(s): Pintler Creek Trailhead, Middle Fork of Rock Creek, Mt.
Haggin Wildlife Management Area

Relative abundance: Locally common to abundant

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22914,
BRY C-23093, BRY C-23805, BRY C-23810

Cladonia coniocraea (Flörke) Spreng.

Growth form: Squamulose with podetia

Substrate: Lignum, decomposing wood, humic soil, soil

Site(s): East Fork Bitterroot River Trail, McCart Lookout Trail,
Pintler Creek Trailhead, Middle Fork of Rock Creek, Ten
Mile Creek, along U.S.F.S. Road #2483

Relative abundance: Locally common

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

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22822,
BRY C-22873, BRY C-22915, BRY C-23094, BRY C-23095,
BRY C-23782, BRY C-23798

Cladonia deformis (L.) Hoffm.

Growth form: Squamulose with podetia

Substrate: Decomposing wood, humic soil

Site(s): Vicinity of Fourmile Basin Lakes

Relative abundance: Rare to locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-23639,
BRY C-23640

Cladonia ecmocyna Leighton

Growth form: Squamulose with podetia

Substrate: Humic soil, conifer duff, soil

Site(s): East Fork Bitterroot River Trail, McCart Lookout Trail,
Pintler Creek Trailhead, Middle Fork of Rock Creek,
Vicinity of Fourmile Basin Lakes, Along U.S.F.S. Road
#2483

Relative abundance: Locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22823
BRY C-22874, BRY C-22916, BRY C-23096, BRY C-23641,
BRY C-23799, BRY C-23811

Cladonia fimbriata (L.) Fr.

Growth form: Squamulose with podetia

Substrate: Humic soil, decomposing wood, moss over soil

Site(s): East Fork Bitterroot River Trail, McCart Lookout Trail,
Pintler Creek Trailhead, Middle Fork of Rock Creek,
Vicinity of Fourmile Basin Lakes, Ten Mile Creek, Along
U.S.F.S. Road #2483, Mt. Haggin Wildlife Management
Area

Relative abundance: Locally common to abundant

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

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22824
BRY C-22875, BRY C-22917, BRY C-23097, BRY C-23642,
BRY C-23643, BRY C-23783, BRY C-23800, BRY C-23806,
BRY C-23812

Cladonia gracilis (L.) Willd.

Growth form: Squamulose with podetia

Substrate: Humic soil

Site(s): McCart Lookout Trail, Pintler Creek Trailhead, Middle
Fork of Rock Creek, Vicinity of Fourmile Basin Lakes

Relative abundance: Locally common

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

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22876
BRY C-22918, BRY C-23098, BRY C-23644, BRY C-23645

Cladonia pocillum (Ach.) O.Rich

Growth form: Squamulose with podetia
Substrate: Soil, moss, decomposing wood
Site(s): Goat Flat, Vicinity of Fourmile Basin Lakes
Relative abundance: Rare to locally common
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium: BRY C-23024,
BRY C-23646, BRY C-23647, BRY C-23648, BRY C-23649

Cladonia pyxidata (L.) Hoffm.

Growth form: Squamulose with podetia
Substrate: Humic soil, moss over soil
Site(s): Pintler Creek Trailhead, Ten Mile Creek, Vicinity of
Fourmile Basin Lakes
Relative abundance: Locally common
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium: BRY C-22919,
BRY C-23784, BRY C-23828

Cladonia stricta (Nyl.) Nyl.

Growth form: Squamulose with podetia
Substrate: Soil
Site(s): Pintler Creek Trailhead, Vicinity of Fourmile Basin
Lakes
Relative abundance: Rare
Pollution sensitivity: Unknown
Comments: This taxon is a new species record for Montana
Deposition of specimens: BYU Herbarium: BRY C-22920,
BRY C-23650

Cladonia sulphurina (Michaux) Fr.

Growth form: Squamulose with podetia
Substrate: Decomposing wood, humic soil
Site(s): East Fork Bitterroot River Trail, McCart Lookout Trail
Pintler Creek Trailhead, Middle Fork of Rock Creek,
Vicinity of Fourmile Basin Lakes
Relative abundance: Locally common
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium: BRY C-22825
BRY C-22877, BRY C-22921, BRY C-23099, BRY C-23651,
BRY C-23652, BRY C-23813

Coelocaulon aculeatum (Schreber) Link

Growth form: Fruticose
Substrate: Soil (vagrant)
Site(s): Goat Flat, Vicinity of Fourmile Basin Lakes
Relative abundance: Common to abundant
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium: BRY C-23026,
BRY C-23653

Collema cristatum (L.) Weber *ex* Wigg.

Growth form: Foliose
Substrate: Rock
Site(s): Goat Flat
Relative abundance: Rare
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium: BRY C-23025

Cyphellium lucidum (Th. Fr.) Th. Fr.

Growth form: Crustose
Substrate: Lignum
Site(s): Pintler Creek Trailhead, Vicinity of Fourmile Basin
Lakes
Relative abundance: Rare to locally common
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium: BRY C-23814,
BRY C-23829

Cyphellium tigillare (Ach.) Ach.

Growth form: Crustose

Substrate: Conifer bark, lignum

Site(s): Pintler Creek Trailhead

Relative abundance: Locally common to abundant

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22922

BRY C-22923, BRY C-22924

Dactylina madreporiformis (Ach.) Tuck.

Growth form: Fruticose

Substrate: Soil, detritus

Site(s): Goat Flat

Relative abundance: Locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-23027

Dermatocarpon luridum (With.) Laundon

Growth form: Foliose, umbilicate

Substrate: Rock in stream

Site(s): Pintler Creek Trailhead

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22925

Dermatocarpon miniatum (L.) Mann

Growth form: Foliose, umbilicate

Substrate: Rock

Site(s): Goat Flat

Relative abundance: Locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-23028

Dermatocarpon reticulatum Magnusson

Growth form: Foliose

Substrate: Rock

Site(s): Goat Flat

Relative abundance: Locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-23029

Dimelaena oreina (Ach.) Norman

Growth form: Crustose with effigurate margins

Substrate: Rock

Site(s): East Fork Bitterroot River Trail

Relative abundance: Rare to locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22826

Diploschistes muscorum (Scop.) R. Sant.

Growth form: Crustose

Substrate: Soil

Site(s): Goat Flat, Vicinity of Fourmile Basin Lakes

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-23030,
BRY C-23654

Diploschistes scruposus (Schreber) Norman

Growth form: Crustose

Substrate: Rock

Site(s): Pintler Creek Trailhead

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22926

Diplotomma alboatrum (Hoffm.) Flotow

Growth form: Crustose

Substrate: Lignum

Site(s): Vicinity of Fourmile Basin Lakes

Relative abundance: Rare to locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-23830

Diplotomma penichrum (Tuck.) Szat.

Growth form: Crustose

Substrate: Lignum

Site(s): Vicinity of Fourmile Basin Lakes

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-23831

Endocarpon pulvinatum Th. Fr.

Growth form: Squamulose

Substrate: Rock

Site(s): Goat Flat, Basalt dike (along State Road #274)

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-23031,
BRY C-23791

Fulgensia bracteata (Hoffm.) Räsänen

Growth form: Crustose

Substrate: Soil

Site(s): Goat Flat

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-23032

Hypocenomyce scalaris (Ach. ex Liljeblad) M. Choisy

Growth form: Foliose

Substrate: Lignum

Site(s): Vicinity of Fourmile Basin Lakes

Relative abundance: Rare to locally common

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

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-23832

Hypogymnia austerodes (Nyl.) Räsänen

Growth form: Foliose

Substrate: Conifer bark, detritus, lignum, soil

Site(s): Pintler Creek Trailhead, Goat Flat, Middle Fork of Rock
Creek, Vicinity of Fourmile Basin Lakes

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22927
BRY C-23033, BRY C-23100, BRY C-23101, BRY C-23102,
BRY C-23655

Hypogymnia imshaugii Krog

Growth form: Foliose

Substrate: Conifer bark, lignum

Site(s): East fork Bitterroot River Trail, Pintler Creek Trailhead,
Middle Fork of Rock Creek

Relative abundance: Common to abundant

Pollution sensitivity: Intermediately sensitive to ozone (Ryan
1990)

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22827
BRY C-22928, BRY C-22929, BRY C-22930, BRY C-22931,
BRY C-23103, BRY C-23104, BRY C-23105, BRY C-23106

Hypogymnia physodes (L.) Nyl.

Growth form: Foliose

Substrate: Conifer bark, lignum

Site(s): Pintler Creek Trailhead, Middle Fork of Rock Creek

Relative abundance: Locally common

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

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22932

BRY C-22933, BRY C-23107, BRY C-23108, BRY C-23109

Lecanora argopholis (Ach.) Ach.

Growth form: Crustose

Substrate: Rock

Site(s): East Fork Bitterroot River Trail

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22828

Lecanora cenisia Ach.

Growth form: Crustose

Substrate: Rock

Site(s): East Fork Bitterroot River Trail, McCart Lookout Trail,
Pintler Creek Trailhead, Vicinity of Fourmile Basin Lakes

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22829

BRY C-22878, BRY C-22934, BRY C-23618

Lecanora epibryon (Ach.) Ach.

Growth form: Crustose

Substrate: Soil

Site(s): Goat Flat

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-23034

Lecanora garovaglii (Körber) Zahlbr.

Growth form: Crustose with effigurate margins
Substrate: Rock
Site(s): Goat Flat
Relative abundance: Locally common
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium: BRY C-23035

Lecanora hageni (Ach.) Ach.

Growth form: Crustose, obsolete
Substrate: Polypore growing on Quaking Aspen trunk, detritus,
Populus tremuloides
Site(s): Pintler Creek Trailhead, Vicinity of Fourmile Basin
Lakes
Relative abundance: Rare to locally common
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium: BRY C-22935,
BRY C-23656, BRY C-23815

Lecanora impudens Degel.

Growth form: Crustose
Substrate: Conifer bark
Site(s): Middle Fork of Rock Creek
Relative abundance: Rare
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium: BRY C-23110,
BRY C-23111

Lecanora novomexicana (B. de Lesd.) Zahlbr.

Growth form: Crustose with effigurate margins
Substrate: Rock
Site(s): Goat Flat, Vicinity of Fourmile Basin Lakes
Relative abundance: Common
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium: BRY C-23036
BRY C-23066, BRY C-23619

Lecanora polytropa (Hoffm.) Rabenh.

Growth form: Crustose to obsolete

Substrate: Rock

Site(s): McCart Lookout Trail, Pintler Creek Trailhead, Goat Flat.
Middle Fork of Rock Creek, Ten Mile Creek, Basalt dike
(along State Road #274)

Relative abundance: Rare to locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22879
BRY C-22936, BRY C-23064, BRY C-23112, BRY C-23785,
BRY C-23792

Lecanora rupicola (L.) Zahlbr.

Growth form: Crustose

Substrate: Rock

Site(s): Goat Flat, East Fork Bitterroot River Trail, McCart
Lookout Trail, Pintler Creek Trailhead, Vicinity of
Fourmile Basin Lakes

Relative abundance: Rare to locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22830
BRY C-22880, BRY C-22937, BRY C-23037, BRY C-23065,
BRY C-23620

Lecanora saligna (Schrader) Zahlbr.

Growth form: Crustose

Substrate: Lignum

Site(s): Pintler Creek Trailhead

Relative abundance: Rare

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

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22938

Lecanora varia (Hoof.) Ach.

Growth form: Crustose

Substrate: Lignum, Lodgepole Pine

Site(s): East Fork Bitterroot River Trail, Pintler Creek Trailhead,
Vicinity of Fourmile Basin Lakes, Along U.S.F.S. Road
#2483, Mt. Haggin Wildlife Management Area

Relative abundance: Rare to locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22831
BRY C-22939, BRY C-23657, BRY C-23801, BRY C-23807

Lecidea atrobrunnea (Ramond *in* Lam. & DC.) Schaerer

Growth form: Crustose

Substrate: Rock

Site(s): Goat Flat, McCart Lookout Trail, Vicinity of Fourmile
Basin Lakes, Ten Mile Creek

Relative abundance: Common to abundant

Pollution sensitivity: Unknown

Comments: This is one of the most common western saxicolous
lichens.

Deposition of specimens: BYU Herbarium: BRY C-22881
BRY C-22941, BRY C-23038, BRY C-23067, BRY C-23621,
BRY C-237865

Lecidea auriculata Th. Fr.

Growth form: Crustose

Substrate: Rock

Site(s): Pintler Creek Trailhead

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22940

Lecidea elabens Fr.

Growth form: Crustose

Substrate: Lignum

Site(s): Pintler Creek Trailhead

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22942

Lecidea leucothallina Arnold

Growth form: Crustose
Substrate: Rock
Site(s): Vicinity of Fourmile Basin Lakes
Relative abundance: Rare
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium: BRY C-23622

Lecidea rufofusca (Anzi) Nyl.

Growth form: Crustose
Substrate: Lignum
Site(s): Pintler Creek Trailhead
Relative abundance: Rare
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium: BRY C-22943

Lecidea tessellata Flörke

Growth form: Crustose to obsolete
Substrate: Rock
Site(s): East Fork Bitterroot River Trail, Goat Flat, Vicinity of
Fourmile Basin Lakes
Relative abundance: Common
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium: BRY C-22832
BRY C-23068, BRY C-23623

Lecidella euphorea (Flörke) Hertel

Growth form: Crustose
Substrate: Lignum
Site(s): Pintler Creek Trailhead, Vicinity of Fourmile Basin
Lakes
Relative abundance: Rare to locally common
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium: BRY C-22944,
BRY C-23658

Lecidoma demissum (Rutstr.) G. Schneider & Hertel

Growth form: Crustose

Substrate: Moss, soil

Site(s): Pintler Creek Trailhead, Vicinity of Fourmile Basin
Lakes

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22945,
BRY C-23659

Leproloma vouauxii (Hue) Laundon

Growth form: Crustose/leprose

Substrate: Moss over rock

Site(s): East Fork Bitterroot River Trail

Relative abundance: Rare to locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22833

Leptochidium albociliatum (Desmaz.) M. Choisy

Growth form: Minutely foliose

Substrate: Moss over rock

Site(s): East Fork Bitterroot River Trail

Relative abundance: Rare to locally common

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

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22834

Leptogium californicum Tuck.

Growth form: Foliose

Substrate: Moss on rock

Site(s): East Fork Bitterroot River Trail

Relative abundance: Rare

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

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22835

Letharia columbiana (Nutt.) Thomson

Growth form: Fruticose

Substrate: Conifer bark, lignum, Spruce, *Populus tremuloides*

Site(s): East Fork Bitterroot River Trail, McCart Lookout Trail,
Pintler Creek Trailhead, Vicinity of Fourmile Basin Lakes

Relative abundance: Rare to locally common

Pollution sensitivity: Intermediately sensitive to ozone (Ryan
1990)

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22836

BRY C-22882, BRY C-22946, BRY C-22947, BRY C-23660,
BRY C-23661, BRY C-23816

Letharia vulpina (L.) Hue

Growth form: Fruticose

Substrate: Conifer bark, lignum, decomposing wood, Lodgepole
Pine, Doug Fir, *Populus tremuloides*

Site(s): Goat Flat, East Fork Bitterroot River Trail, McCart
Lookout Trail, Pintler Creek Trailhead, Middle Fork of
Rock Creek, Vicinity of Fourmile Basin Lakes

Relative abundance: Locally common to abundant

Pollution sensitivity: Intermediately sensitive to ozone (Ryan
1990)

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22837

BRY C-22883, BRY C-22948, BRY C-22949, BRY C-22950
BRY C-22951, BRY C-22981, BRY C-22983, BRY C-23113,
BRY C-23114, BRY C-23115, BRY C-23662, BRY C-23663,
BRY C-23664, BRY C-23817

Megaspora verrucosa (Ach.) Hafellner & V.Wirth

Growth form: Crustose

Substrate: Soil, detritus, lignum

Site(s): Goat Flat

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-23039

Melanelia albertana (Ahti) Essl.

Growth form: Foliose

Substrate: Moss over granite

Site(s): East Fork Bitterroot River Trail

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: This taxon is a new species record for Montana

Deposition of specimens: BYU Herbarium: BRY C-22838

Melanelia granulosa (Lynge) Essl.

Growth form: Foliose

Substrate: Rock

Site(s): Pintler Creek Trailhead

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22952

Melanelia substygia (Räsänen) Essl.

Growth form: Foliose

Substrate: Rock

Site(s): Vicinity of Fourmile Basin Lakes

Relative abundance: Rare to locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-23624

Micarea assimilata (Nyl.)

Growth form: Crustose

Substrate: Moss over soil, soil, detritus

Site(s): Pintler Creek Trailhead, Vicinity of Fourmile Basin
Lakes

Relative abundance: Rare to locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22953,
BRY C-23665

Mycobilimbia berengeriana (Massal.) Hafellner & V. Wirth

Growth form: Crustose

Substrate: Humic soil

Site(s): Middle Fork of Rock Creek

Relative abundance: Rare to locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-23116

Nephroma parile (Ach.) Ach.

Growth form: Foliose

Substrate: Moss over rock, rock

Site(s): East Fork Bitterroot River Trail, McCart Lookout Trail

Relative abundance: Locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22839
BRY C-22884

Ochrolechia androgyna (Hoffm.) Arnold

Growth form: Crustose

Substrate: Lignum, conifer bark, Spruce

Site(s): East Fork Bitterroot River Trail, Pintler Creek Trailhead,
Middle Fork of Rock Creek, Vicinity of Fourmile Basin
Lakes, Mt. Haggin Wildlife Management Area

Relative abundance: Rare to locally common

Pollution sensitivity: Sensitive to sulfur dioxide (Wetmore
1987)

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22840
BRY C-22954, BRY C-23117, BRY C-23666, BRY C-23808,
BRY C-23825, BRY C-23833

Ochrolechia upsaliensis (L.) Massal.

Growth form: Crustose

Substrate: Soil, detritus, moss over soil

Site(s): Goat Flat, Vicinity of Fourmile Basin Lakes

Relative abundance: Rare to locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-23041,
BRY C-23667

Pannaria conoplea (Ach.) Bory

Growth form: Squamulose

Substrate: Soil, moss over soil

Site(s): Vicinity of Fourmile Basin Lakes

Relative abundance: Rare to locally common

Pollution sensitivity: Unknown

Comments: This taxon is a new species record for Montana

Deposition of specimens: BYU Herbarium: BRY C-23673,
BRY C-23674

Pannaria pezizoides (Weber) Trevisan

Growth form: Squamulose

Substrate: Moss

Site(s): Vicinity of Fourmile Basin Lakes

Relative abundance: Rare to locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-23675

Parmelia saxatilis (L.) Ach.

Growth form: Foliose

Substrate: Rock

Site(s): East Fork Bitterroot River Trail, Vicinity of Fourmile
Basin Lakes, Pintler Creek Trailhead

Relative abundance: Rare to locally common

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

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22841,
BRY C-23625, BRY C-23818

Parmelia sulcata Taylor

Growth form: Foliose

Substrate: Rock, decomposing wood, conifer bark

Site(s): East Fork Bitterroot River Trail, Pintler Creek Trailhead,
Middle Fork of Rock Creek

Relative abundance: Rare to locally common

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

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22842
BRY C-22955, BRY C-22956, BRY C-22984, BRY C-22985,
BRY C-23118, BRY C-23119

Parmeliopsis ambigua (Wulfen *in* Jacq.) Nyl.

Growth form: Foliose

Substrate: Lignum, Doug Fir, conifer bark

Site(s): East Fork Bitterroot River Trail, McCart Lookout Trail,
Middle Fork of Rock Creek, Vicinity of Fourmile Basin
Lakes, Pintler Creek Trailhead

Relative abundance: Common to abundant

Pollution sensitivity: Intermediately sensitive to sulfur dioxide
(Wetmore 1987);

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22843
BRY C-22885, BRY C-22986, BRY C-23120, BRY C-23121,
BRY C-23669, BRY C-23819

Parmeliopsis hyperopta (Ach.) Arnold

Growth form: Foliose

Substrate: Lignum, Spruce

Site(s): East Fork Bitterroot River Trail, McCart Lookout Trail,
Middle Fork of Rock Creek, Vicinity of Fourmile Basin
Lakes, Pintler Creek Trailhead

Relative abundance: Rare to locally common

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

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22844
BRY C-22886, BRY C-23122, BRY C-23668, BRY C-23820

Peltigera aphthosa (L.) Willd.

Growth form: Foliose

Substrate: Humic soil, moss

Site(s): East Fork Bitterroot River Trail, McCart Lookout Trail,
Pintler Creek Trailhead, Middle Fork of Rock Creek,
Vicinity of Fourmile Basin Lakes

Relative abundance: Locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22845
BRY C-22887, BRY C-22957, BRY C-23123, BRY C-23670,
BRY C-23821

Peltigera canina (L.) Willd.

Growth form: Foliose

Substrate: Soil, decomposing wood, moss over rock

Site(s): East Fork Bitterroot River Trail, McCart Lookout Trail,
Pintler Creek Trailhead, Middle Fork of Rock Creek,
Vicinity of Fourmile Basin Lakes

Relative abundance: Locally common

Pollution sensitivity: Sensitive to ozone (Ryan 1990)

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22846
BRY C-22888, BRY C-22958, BRY C-23124, BRY C-23671
BRY C-23672, BRY C-23822

Peltigera collina (Ach.) Schrader

Growth form: Foliose

Substrate: Rock

Site(s): East Fork Bitterroot River Trail

Relative abundance: Rare

Pollution sensitivity: Sensitive to ozone (Ryan 1990)

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22847

Peltigera malacea (Ach.) Funck

Growth form: Foliose

Substrate: Soil

Site(s): Vicinity of Fourmile Basin Lakes, Pintler Creek
Trailhead

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-23676,
BRY C-23823

Peltigera rufescens (Weis) Humb.

Growth form: Foliose

Substrate: Soil

Site(s): Pintler Creek Trailhead, Goat Flat

Relative abundance: Rare

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

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22959
BRY C-23040

Peltigera venosa (L.) Hoffm.

Growth form: Foliose

Substrate: Soil, moss

Site(s): East Fork Bitterroot River Trail, Pintler Creek Trailhead,
Goat Flat, Middle Fork of Rock Creek, Vicinity of Fourmile
Basin Lakes

Relative abundance: Rare to locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22848
BRY C-22960, BRY C-23042, BRY C-23125, BRY C-23677,
BRY C-23824

Phaeophyscia decolor (Kashi.) Essl.

Growth form: Foliose
Substrate: Rocks in stream
Site(s): Vicinity of Ten Mile Creek (along F.S. Road # 2483)
Relative abundance: Rare
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium: BRY C-23787

Phaeophyscia endococcina (Körber) Moberg

Growth form: Foliose
Substrate: Rock, conifer bark
Site(s): Pintler Creek Trailhead
Relative abundance: Rare
Pollution sensitivity: Unknown
Comments: None
Deposition of specimens: BYU Herbarium: BRY C-22961
BRY C-22962, BRY C-23787

Phaeophyscia orbicularis (Necker) Moberg

Growth form: Foliose
Substrate: Rock
Site(s): East Fork Bitterroot River Trail
Relative abundance: Locally common
Pollution sensitivity: Sensitive to ozone; Intermediately
sensitive to sulfur dioxide; sensitive to fluoride (Ryan
1990)
Comments: None
Deposition of specimens: BYU Herbarium: BRY C-22849

Phaeophyscia rubropulchra (Degel.) Moberg

Growth form: Foliose
Substrate: On Parmelia saxatilis over rock
Site(s): East Fork Bitterroot River Trail
Relative abundance: Locally common
Pollution sensitivity: Unknown
Comments: This taxon is a new species record for Montana
Deposition of specimens: BYU Herbarium: BRY C-22850

Phaeorrhiza nimbosa (Fr.) Mayrh. & Poelt

Growth form: Crustose-squamulose

Substrate: Soil, detritus

Site(s): Goat Flat

Relative abundance: Rare to locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-23043

Physcia biziana (Massal.) Zahlbr.

Growth form: Foliose

Substrate: Rock

Site(s): East Fork Bitterroot River Trail, McCart Lookout Trail

Relative abundance: Rare to locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22851
BRY C-22889

Physcia caesia (Hoffm.) Fűrnr.

Growth form: Foliose

Substrate: Rock

Site(s): Pintler Creek Trailhead, Vicinity of Fourmile Basin
Lakes

Relative abundance: Rare

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

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22963,
BRY C-23626

Physcia dubia (Hoffm.) Lettau

Growth form: Foliose

Substrate: Rock

Site(s): Basalt dike (along State Road #274)

Relative abundance: Rare

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

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-23793

Physcia phaea (Tuck.) Thomson

Growth form: Foliose

Substrate: Rock

Site(s): Pintler Creek Trailhead

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22964

Physconia detersa (Nyl.) Poelt

Growth form: Foliose

Substrate: Rock

Site(s): East Fork Bitterroot River Trail

Relative abundance: Rare

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

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22852

Physconia muscigena (Ach.) Poelt

Growth form: Foliose

Substrate: Soil, rock, moss

Site(s): Goat Flat, Vicinity of Fourmile Basin Lakes

Relative abundance: Locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-23044,
BRY C-23678, BRY C-23679, BRY C-23680, BRY C-23781

Physconia perisidiosa (Erichsen) Moberg

Growth form: Foliose

Substrate: Moss over rock

Site(s): East Fork Bitterroot River Trail

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22853

Platismatia glauca (L.) Culb. & C. Culb.

Growth form: Foliose

Substrate: Decomposing wood, lignum, conifer bark

Site(s): East Fork Bitterroot River Trail, Pintler Creek Trailhead,
Middle Fork of Rock Creek

Relative abundance: Rare

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

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22855
BRY C-22965, BRY C-22987, BRY C-23126, BRY C-23127,
BRY C-23128

Porpidia macrocarpa (DC. in Lam. & DC.) Hertel & Schwab

Growth form: Crustose

Substrate: Rock

Site(s): McCart Lookout Trail

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22890

Protoparmelia badia (Hoffm.) Hafellner

Growth form: Crustose

Substrate: Rock

Site(s): Goat Flat, East Fork Bitterroot River Trail, Pintler Creek
Trailhead, Vicinity of Fourmile Basin Lakes

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22856
BRY C-22966, BRY C-23069, BRY C-23627

Pseudephebe minuscula (Nyl. ex Arnold) Brodo & D. Hawksw.

Growth form: Fruticose

Substrate: Rock

Site(s): Goat Flat, Pintler Creek Trailhead

Relative abundance: Rare to locally common

Pollution sensitivity: Intermediately sensitive to ozone (Ryan
1990)

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22967,
BRY C-23045

Pseudephebe pubescens (L.) M. Choisy

Growth form: Fruticose

Substrate: Rock

Site(s): Pintler Creek Trailhead, Goat Flat, Vicinity of Fourmile Basin Lakes

Relative abundance: Rare to locally common

Pollution sensitivity: Intermediately sensitive to ozone (Ryan 1990)

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22968
BRY C-23046, BRY C-23628

Psora decipiens (Hedwig) Hoffm.

Growth form: Squamulose

Substrate: Soil

Site(s): Goat Flat

Relative abundance: Rare to locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-23047

Psora himalayana (Church. Bab.) Timdal

Growth form: Squamulose

Substrate: Soil

Site(s): Storm Lake Pass, Vicinity of Fourmile Basin Lakes

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-23048,
BRY C-23682

Psora rubriformis (Ach.) Hook.

Growth form: Squamulose

Substrate: Soil

Site(s): Goat Flat

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-23049

Psora tuckermanii R. Anderson ex Timdal

Growth form: Squamulose

Substrate: Soil

Site(s): Goat Flat, Vicinity of Fourmile Basin Lakes

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-23050,
BRY C-23683

Psoroma hypnorum (Vahl) Gray

Growth form: Squamulose

Substrate: Moss over rock, mossy soil

Site(s): East Fork Bitterroot River Trail, Middle Fork of Rock
Creek, Vicinity of Fourmile Basin Lakes

Relative abundance: Rare to locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22857,
BRY C-23129, BRY C-23684, BRY C-23685

Rhizocarpon geographicum (L.) DC.

Growth form: Crustose

Substrate: Rock

Site(s): Vicinity of Fourmile Basin Creek

Relative abundance: Common to abundant

Pollution sensitivity: Sensitive to fluoride (Ryan 1990)

Comments: This is one of the most common western saxicolous
lichens.

Deposition of specimens: BYU Herbarium: BRY C-23629

Rhizocarpon intermediellum Räsänen

Growth form: Crustose

Substrate: Rock

Site(s): Goat Flat

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-23051

Rhizoplaca chrysoleuca (Sm.) Zopf

Growth form: Foliose, umbilicate

Substrate: Rock

Site(s): McCart Lookout Trail

Relative abundance: Locally common

Pollution sensitivity: Sensitive to sulfur dioxide, nitrous oxides,
and PAN (Ryan 1990)

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22891

Rhizoplaca melanophthalma (DC. in Lam. & DC.) Leuck. & Poelt

Growth form: Foliose, umbilicate

Substrate: Rock

Site(s): Goat Flat, East Fork Bitterroot River Trail, McCart
Lookout Trail, Pintler Creek Trailhead, Vicinity of
Fourmile Basin Lakes, Basalt dike (along State Road #274)

Relative abundance: Rare to locally common

Pollution sensitivity: Sensitive to sulfur dioxide (Hale 1982)

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22858
BRY C-22892, BRY C-22969, BRY C-23630, BRY C-23794

Rinodina turfacea (Wahlenb.) Körber

Growth form: Crustose

Substrate: Detritus

Site(s): Goat Flat

Relative abundance: Rare to locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-23052

Solorina bispora Nyl.

Growth form: Foliose

Substrate: Soil

Site(s): Goat Flat

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-23053

Solorina crocea (L.) Ach.

Growth form: Foliose

Substrate: Soil

Site(s): Vicinity of Fourmile Basin Lakes

Relative abundance: Locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-23686

Solorina spongiosa (Ach.) Anzi

Growth form: Foliose

Substrate: Moss on wet drip wall

Site(s): Vicinity of Fourmile Basin Lakes

Relative abundance: Rare to locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-23687

Sporastatia polyspora(Nyl.) Grumm.

Growth form: Crustose

Substrate: Rock

Site(s): Goat Flat

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-23054

Sporastatia testudinea (Ach.) Massal.

Growth form: Crustose

Substrate: Rock

Site(s): Goat Flat, Vicinity of Fourmile Basin Lakes

Relative abundance: Common to abundant

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-23055,
BRY C-23631

Staurothele drun... (Tuck.) Tuck.

Growth form: Crustose

Substrate: Rock

Site(s): Goat Flat

Relative abundance: Locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-23056

Staurothele fissa (Taylor) Zwackh

Growth form: Crustose

Substrate: Rocks in stream

Site(s): Ten Mile Creek (along F.S. Road #2483)

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-23788

Stereocaulon alpinum Laurer *ex* Funck

Growth form: Fruticose

Substrate: Soil

Site(s): Goat Flat, Middle Fork of Rock Creek

Relative abundance: Locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-23057,
BRY C-23130

Tephromela armeniaca (DC.) Hertel & Rambold

Growth form: Crustose

Substrate: Rock

Site(s): Goat Flat

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-23070

Thamnolia subuliformis (Ehrh.) Culb.

Growth form: Fruticose

Substrate: Soil, detritus

Site(s): Goat Flat, Vicinity of Fourmile Basin Lakes

Relative abundance: Rare to locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-23058,
BRY C-23688

Thelomma ocellatum (Körber) Tibell

Growth form: Crustose

Substrate: Lignum

Site(s): Pintler Creek Trailhead

Relative abundance: Rare to locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-23826

Toninia caeruleonigricans (Lightf.) Th. Fr.

Growth form: Squamulose

Substrate: Soil

Site(s): Vicinity of Fourmile Basin Lakes

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-23689

Trapeliopsis granulosa (Hoffm.) Lumbsch.

Growth form: Crustose

Substrate: Lignum, decomposing wood, humic soil

Site(s): McCart Lookout Trail, Pintler Creek Trailhead, Vicinity
of Fourmile Basin Lakes, Along U.S.F.S. Road #2483

Relative abundance: Locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22893
BRY C-22970, BRY C-22982, BRY C-23690, BRY C-23691,
BRY C-23802

Tremolechia atrata (Ach.) Hertel

Growth form: Crustose

Substrate: Rock

Site(s): Vicinity of Fourmile Basin Lakes

Relative abundance: Rare to locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-23632

Tuckermannopsis chlorophylla (Willd. in Humb.) Hale

Growth form: Foliose

Substrate: Lignum, conifer bark

Site(s): East Fork Bitterroot River Trail, Pintler Creek Trailhead,
Middle Fork of Rock Creek

Relative abundance: Rare

Pollution sensitivity: Sensitive to sulfur dioxide (Ryan 1990)

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22859

BRY C-22971, BRY C-22972, BRY C-22988, BRY C-22989,
BRY C-23131, BRY C-23132

Tuckermannopsis merrillii (Du Rietz) Hale

Growth form: Foliose-fruticose

Substrate: Conifer bark, *Populus tremuloides*

Site(s): McCart Lookout Trail, Pintler Creek Trailhead

Relative abundance: Rare

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

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22894

BRY C-22973, BRY C-23827

Tuckermannopsis pinastri (Scop.) Hale

Growth form: Foliose

Substrate: Lignum

Site(s): East Fork Bitterroot River Trail

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22860

BRY C-22990

Tuckermannopsis platyphylla (Tuck.) Hale

Growth form: Foliose

Substrate: Lignum, conifer bark

Site(s): Pintler Creek Trailhead, Middle Fork of Rock Creek

Relative abundance: Rare to locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22974

BRY C-22975, BRY C-23133, BRY C-23134

Umbilicaria decussata (Vill.) Zahlbr.

Growth form: Foliose, umbilicate

Substrate: Rock

Site(s): Goat Flat, Basalt dike (along State Road #274)

Relative abundance: Rare to locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-23795

Umbilicaria hyperborea (Ach.) Hoffm.

Growth form: Foliose, umbilicate

Substrate: Rock

Site(s): McCart Lookout Trail, Pintler Creek Trailhead,

Vicinity of Fourmile Basin Lakes

Relative abundance: Locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22895

BRY C-22976, BRY C-23633

Umbilicaria krascheninnikovii (Savacz) Zahlbr.

Growth form: Foliose, umbilicate

Substrate: Rock

Site(s): Goat Flat, Basalt dike (along State Road #274)

Relative abundance: Locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-23059,

BRY C-23796

Umbilicaria torrefacta (Lightf.) Schrader

Growth form: Foliose, umbilicate

Substrate: Rock

Site(s): East Fork Bitterroot River Trail, McCart Lookout Trail,
Pintler Creek Trailhead

Relative abundance: Locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22861
BRY C-22896, BRY C-22977

Umbilicaria vellea (L.) Ach.

Growth form: Foliose, umbilicate

Substrate: Rock

Site(s): East Fork Bitterroot River Trail, Pintler Creek Trailhead,
Vicinity of Fourmile Basin Lakes

Relative abundance: Locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22862
BRY C-22978, BRY C-23692

Umbilicaria virginis Schaerer

Growth form: Foliose, umbilicate

Substrate: Rock

Site(s): Goat Flat, Vicinity of Fourmile Basin Lakes

Relative abundance: Common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-23693

Usnea alpina Mot.

Growth form: Fruticose

Substrate: Lignum

Site(s): Pintler Creek Trailhead

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22979

Xanthoparmelia wyomingica (Gyelnik) Hale

Growth form: Foliose

Substrate: Soil, rock

Site(s): Goat Flat, Vicinity of Fourmile Basin Lakes

Relative abundance: Rare to locally common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-23060,
BRY C-23694

Xanthoria elegans (Link) Th. Fr.

Growth form: Minutely fruticose

Substrate: Rock

Site(s): Goat Flat, East Fork Bitterroot River Trail,
Vicinity of Fourmile Basin Lakes

Relative abundance: Common

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22863
BRY C-23061, BRY C-23634

Xanthoria fallax (Hepp. in Arnold) Arnold

Growth form: Foliose

Substrate: Lignum

Site(s): East Fork Bitterroot River Trail, McCart Lookout Trail

Relative abundance: Rare to locally common

Pollution sensitivity: Sensitive to intermediately sensitive to
sulfur dioxide; sensitive to nitrous oxides and Pan (Ryan
1990)

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22864
BRY C-22897

Xylographa abietina (Pers.) Zahlbr.

Growth form: Obsolete, endoxylic

Substrate: Lignum

Site(s): Pintler Creek Trailhead

Relative abundance: Rare

Pollution sensitivity: Unknown

Comments: None

Deposition of specimens: BYU Herbarium: BRY C-22980

OBSERVATIONS AND CONCLUSIONS:

1. The lichen flora of the Anaconda-Pintler Wilderness Area is diverse and well developed. From our collections at the five reference sites within the wilderness we have identified a total of 143 species in 65 genera. An addition 18 species and 6 genera, not found in the wilderness area, were collected from the five reference sites established between the eastern boundary of the wilderness and the now defunct Anaconda Copper Smelter. Our collections include four new species records for Montana. All growth forms are well represented; however the flora is dominated by crustose species (41%, 66 species), followed closely by foliose species (35%, 56 species). Fruticose lichens make up 10% of the flora (17 species) while squamulose species comprise 14% of the flora (22 species). Generally, this growth form pattern seems to be typical of the lichen floras of western Montana and the Pacific Northwest. However, other Intermountain Area lichen floras are more completely dominated by crustose species (48% in the Bridger Wilderness Area, and 50% in the High Uintas Wilderness Area; with foliose species representing only 28% and 29% of the lichen floras of those wildernesses).

In contrast four of the five reference sites east of the wilderness were notably depauperate in lichens, yielding only 21 total species in 13 genera. The only exception to this pattern was the Fourmile Basin Lakes reference site which is located very close to the northeast corner of the wilderness. The lichen flora at this reference site appears to be quite similar to the other reference sites in the wilderness with 70 species in 41 genera.

The growth form pattern of the lichens collected in the four reference sites nearest the smelter was also decidedly different from the general pattern described for the five wilderness reference sites. Again crustose species dominated the flora (43%, 9 species); however, the distribution of the other growth forms departed significantly from the pattern for the wilderness: foliose species (24%, 5 species), fruticose species (4%, 1 species), and squamulose species (29%, 6 species). This pattern (low species diversity and reduced occurrence of foliose and fruticose species) very clearly indicates that during operation of the smelter significant damage was done to the most sensitive components of the lichen flora. This was likely due to three major factors: 1)

toxicity of smelter emissions; 2) extensive removal of appropriate substrates; and 3) general habitat destruction.

2. During this study lichens were collected from 5 basic substrates: rocks, lignum/bark, moss/detritus, soil and the thalli of other lichen species. A total of 61 species (38% of the flora) were collected from various rock substrates. Bark/lignum substrates were second in importance accounting for 36 species (22% of the flora). Twenty five species (16% of the flora) were collected from moss/detritus substrates with 37 species (23% of the flora) from the soil. Finally, 2 species (1% of the flora) occurred as epiphytes on other lichen species. Generally, this substrate pattern is typical for most of the Intermountain Area.

Substrate distribution patterns at the four reference sites closest to the smelter departed significantly from the patterns for other 6 reference sites (five of which were in the wilderness area). The percentage of rock lichens increased significantly (53%, 11 species), while the lichens on all other substrates declined: soil (19%, 4 species), moss/detritus (14%, 3 species), bark/lignum (14%, 3 species), and epiphytes (0 species). Again this shift in substrate patterns also reflects the severe impact of the copper smelter on the lichen flora at the four reference sites closest to the smelter. The general reduction in bark species is most likely related to the lack of mature tree substrates, compounded by the toxicity of smelter generated pollutants.

3. High species diversity as well as abundance of all basic growth forms indicates that the lichen communities within the Anaconda-Pintler Wilderness Area are generally healthy and not impacted by air pollutants. However, some lichen species, which are particularly sensitive to air pollutants, were either rare or absent in the wilderness, suggesting that there might be some residual air pollution impact on the lichen flora. Evaluation of elemental analysis data along with additional sampling within old-growth areas of the wilderness should provide insights on this issue.
4. The abundance of sensitive indicator species at all reference sites in or near the wilderness {East Fork Bitterroot River Trail (20 spp.), McCart Lookout Trail (14 spp.), Middle Fork Rock Creek (18 spp.), Pintler Creek Trail (26 spp.), Fourmile Basin

Lakes (15 spp.), and Goat Flat (6 spp.)) also documents that the lichen flora in the wilderness area is generally healthy and unimpacted by air pollution. However, the small number and poor development of sensitive indicator species at the four reference sites closest to the smelter {basalt dike along SR #274 (3 spp.), Mount Haggin Wildlife Management Area along U.S. Forest Service road #2483 (3 spp.), Ten Mile Creek (2 spp.), and Mount Haggin Wildlife Management Area at Cabbage Gulch (0 spp.)) shows that the area immediately west of the smelter has been severely impacted, but is showing some preliminary signs of recovery.

5. The absence of necrotic and/or bleached thalli from the reference sites in and near the wilderness also suggests that the lichen flora is generally 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. Specifically, *Letharia vulpina* (bark), *Umbilicaria vellea* (rock), and *Rhizoplaca melanophthalma* (rock) were analyzed for pollutant accumulation (table 1). Thallus concentrations of most pollutant elements are well within background levels (figure 2). However, concentrations of several of the elements were particularly high at some of the reference sites. Specifically, samples of the saxicolous lichen *Rhizoplaca melanophthalma* collected at a basalt dike 12 km west of the now closed Anaconda Copper Smelter showed high levels of arsenic (58 ppm), nickel (90 ppm) and chromium (26 ppm); and relatively high concentrations of copper (98 ppm) and lead (110 ppm). The high levels of arsenic, lead and copper are inevitably related to wind blown dust from either tailings or contaminated soil in the general area of the smelter. Arsenic, lead and copper data from the reference sites west of the basalt dike show a significant reduction in thallus concentrations (arsenic = 2.2-7 ppm; lead = 4-47 ppm and copper = 6-21 ppm). The high nickel and chromium levels are more difficult to explain. The elevated nickel and chromium concentrations in the *Rhizoplaca melanophthalma* is probably, at least in part, related to the basalt substrate. After consulting with Bill Putnam it also appears that fairly high levels of nickel were found in the flue dust from the smelter. Thus windblown nickel from flue dust likely accounts for much of the elevated

TABLE #1: Mean concentrations of potential pollutant elements in sensitive indicator species from air quality biomonitoring reference sites in the Anaconda-Pintler Wilderness Area

	Elements (ppm except where indicated)						
	S%	Cl	K%	Ca%	Ti	V	Cr
<i>Letharia vulpina</i> , McCart Trail, Sample #162	0.08	100	0.27	0.90	110	*n.d.	n.d.
<i>Letharia vulpina</i> , East Fork Bitterroot River, Sample #163	0.04	50	0.22	0.23	36	n.d.	n.d.
<i>Letharia vulpina</i> , Pintler Creek, Sample #164	0.05	n.d.	0.298	0.325	43	n.d.	n.d.
<i>Umbilicaria vellea</i> , Pintler Creek, Sample #165	0.1	n.d.	0.54	0.13	280	n.d.	n.d.
<i>Rhizoplaca melanophthalma</i> , Basalt dike 12 km west of smelter, Sample #166	0.14	230	0.44	0.93	430	n.d.	26
<i>Letharia vulpina</i> , Four Mile Basin, Sample #167	0.07	170	0.18	0.25	76	n.d.	n.d.
<i>Rhizoplaca melanophthalma</i> , Four Mile Basin, Sample #168	0.11	270	0.44	0.82	540	n.d.	6.0
<i>Letharia vulpina</i> , Trail to Goat Flat, Sample #170	0.13	260	0.27	0.22	149	n.d.	n.d.
<i>Letharia vulpina</i> , Middle Fork Rock Creek, Sample #171	0.05	250	0.26	0.48	38	n.d.	n.d.

TABLE #1: Continued

	Elements (ppm except where indicated)						
	Ni	Cu	Zn	Pb	Mn	Fe	Co
<i>Letharia vulpina</i> , McCart Trail, Sample #162	3.3	10	54	12.3	350	330	n.d.
<i>Letharia vulpina</i> , East Fork Bitterroot River, Sample #163	10	6.0	28	4.0	200	170	n.d.
<i>Letharia vulpina</i> , Pintler Creek, Sample #164	5.9	18	41	10	195	220	n.d.
<i>Umbilicaria vellea</i> , Pintler Creek, Sample #165	n.d.	21	240	21	61	1800	n.d.
<i>Rhizoplaca melanophthalma</i> , Basalt dike 12 km west of smelter, Sample #166	90	98	160	110	52	3500	n.d.
<i>Letharia vulpina</i> , Four Mile Basin, Sample #167	1.0	10	39	37	76	430	n.d.
<i>Rhizoplaca melanophthalma</i> , Four Mile Basin, Sample #168	n.d.	17	43	47	102	5300	n.d.
<i>Letharia vulpina</i> , Trail to Goat Flat, Sample #170	n.d.	13	51	23	115	710	n.d.
<i>Letharia vulpina</i> , Middle Fork Rock Creek, Sample #171	n.d.	10	40	6.0	221	190	n.d.

TABLE #1: Continued

	Elements (ppm except where indicated)				
	As	Se	Br	Rb	Sr
<i>Letharia vulpina</i> , McCart Trail, Sample #162	n.d.	n.d.	10	n.d.	14
<i>Letharia vulpina</i> , East Fork Bitterroot River, Sample #163	n.d.	n.d.	8.0	2.0	13
<i>Letharia vulpina</i> , Pintler Creek, Sample #164	n.d.	n.d.	8.0	10	28
<i>Umbilicaria vellea</i> , Pintler Creek, Sample #165	4.0	n.d.	10	25	43
<i>Rhizoplaca melanophthalma</i> , Basalt dike 12 km west of smelter, Sample #166	58	n.d.	5.0	15	53
<i>Letharia vulpina</i> , Four Mile Basin, Sample #167	2.2	n.d.	10	13	16
<i>Rhizoplaca melanophthalma</i> , Four Mile Basin, Sample #168	6.0	n.d.	9.0	33	58
<i>Letharia vulpina</i> , Trail to Goat Flat, Sample #170	7.0	n.d.	13	7.0	14
<i>Letharia vulpina</i> , Middle Fork Rock Creek, Sample #171	n.d.	n.d.	13	17	13

*n.d. = not detectable

Fig. 2 Lichen Biomonitoring Program and Baseline

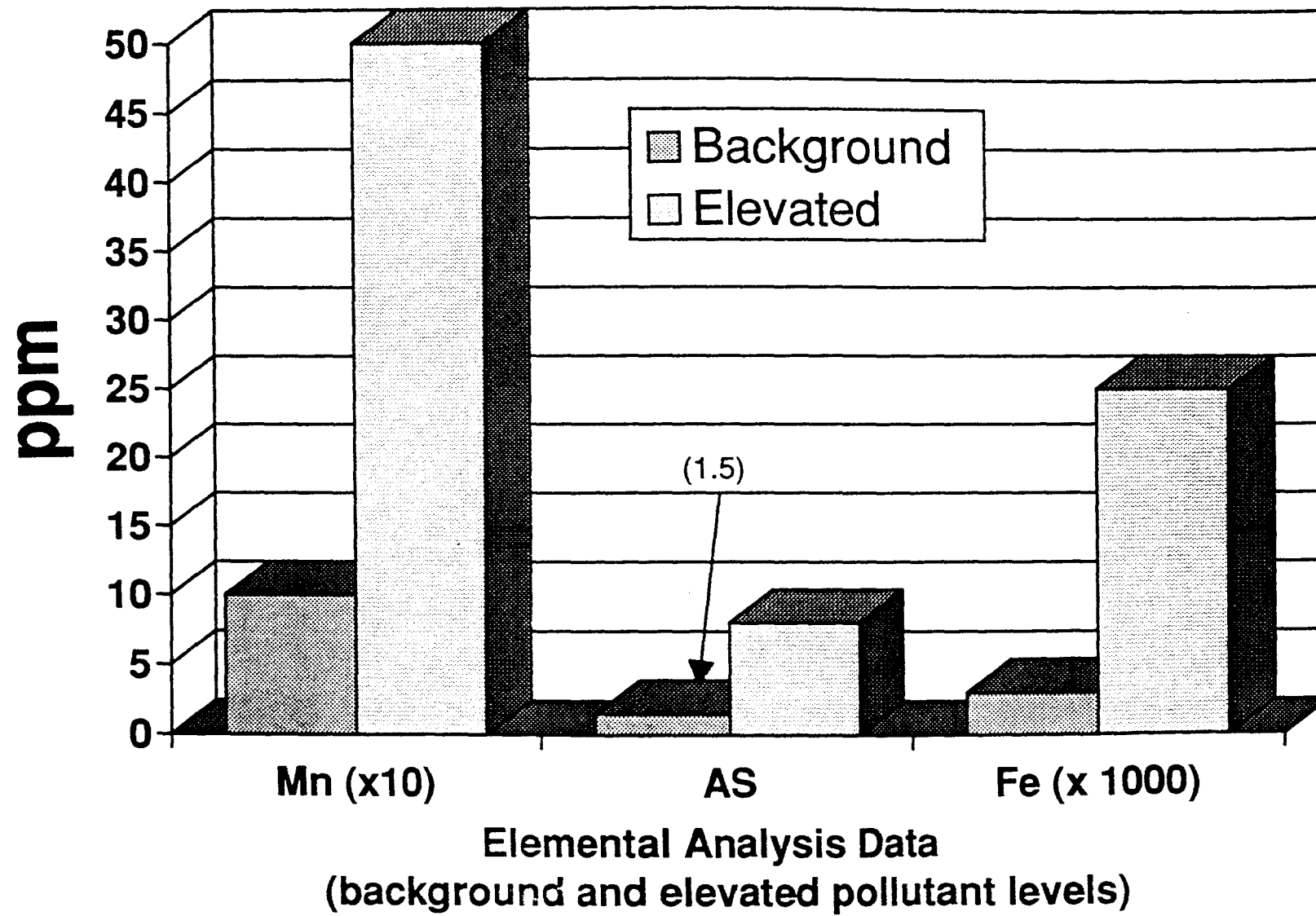


Fig. 2 cont. Lichen Biomonitoring Program and Baseline

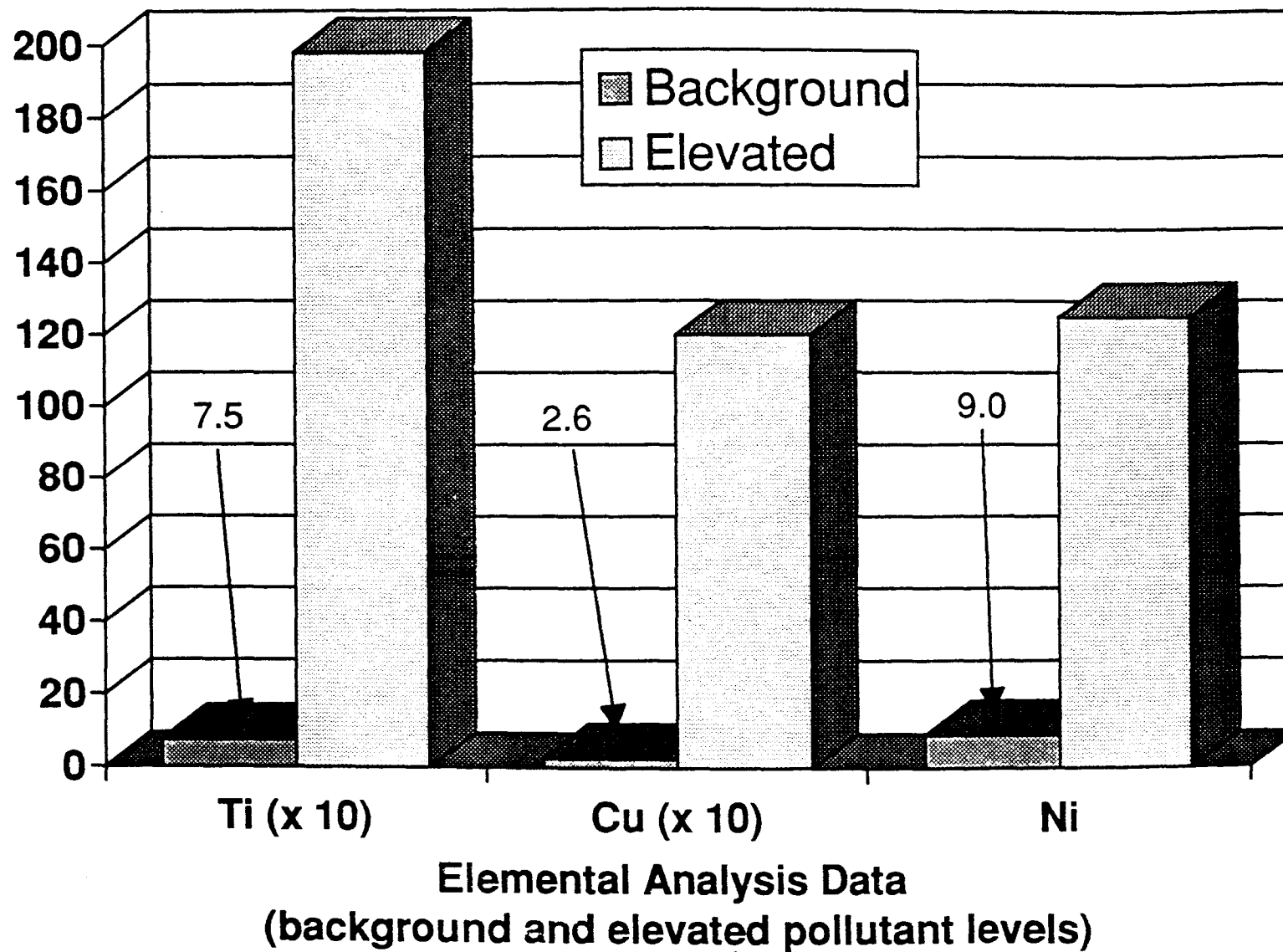
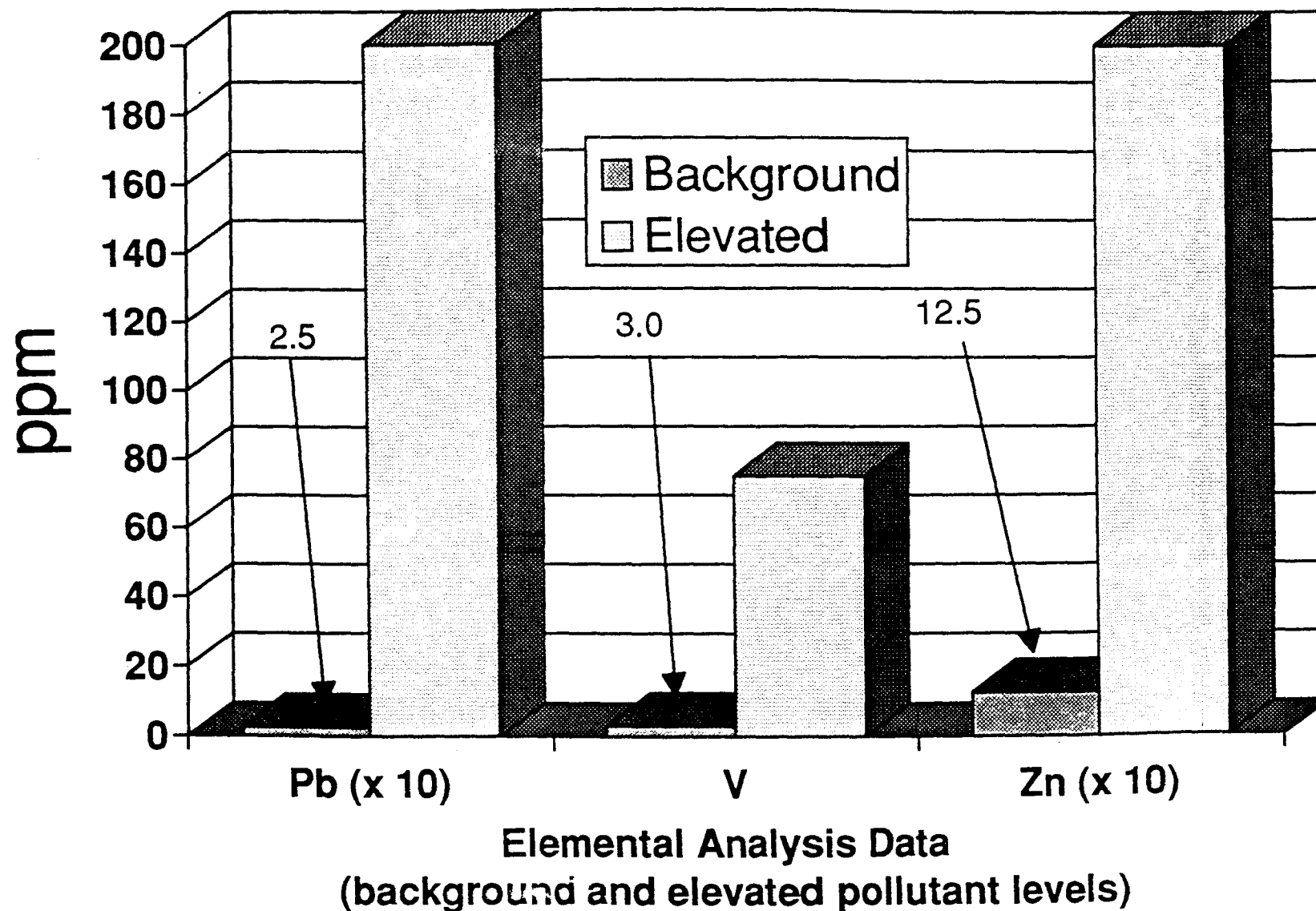


Fig. 2 cont. Lichen Biomonitoring Program and Baseline



nickel concentrations in both the *Rhizoplaca melanophthalma* as well as samples of the corticolous lichen *Letharia vulpina* from Four Mile Basin (1 ppm), Pintler Creek (5.9 ppm), McCart Trail (3.3 ppm) and East Fork of the Bitterroot River (10 ppm). This same pattern for nickel was also observed in the elemental analysis data for the *Letharia vulpina* samples collected at Carlton Lake in the Selway Bitterroot Wilderness Area (8 ppm). Some of the samples also contained moderately high levels of titanium (280-540 ppm) and zinc (160-240 ppm); however, since both of these elements are common components of many soils and rock substrates and are also commonly concentrated by biological systems these values probably represent normal background levels.

7. Careful examination of *Rhizoplaca melanophthalma* thalli collected at the basalt dike showed several significant morphological aberrations that are likely related to the high thallus concentrations of toxic metals. For example, all of the thalli were uncharacteristically small and far lighter in color than unimpacted thalli. Fruiting bodies (apothecia) were also discolored and seemed to have thalline margins that were unusually thick.

RECOMMENDATIONS:

1. Eventually, reference sites should be established in other parts of the wilderness area. This will provide further information about the lichen flora as well as additional baseline information about the status of sensitive indicator species. Particular attention should be paid to old-growth forest areas in and near the wilderness.
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 high levels of pollutant elements or significant changes in relative abundance.

4. Eventually, the additional sensitive indicator material should be analyzed in order to strengthen the baseline.
5. Regular (at least every 2-3 years) monitoring of the lichen flora in the area between the wilderness boundary and the copper smelter should be done in order to effectively document specific recovery patterns.
6. In order to effectively monitor concentrations of nickel, chromium and arsenic; samples of *Rhizoplaca melanophthalma* from the basalt dike and *Letharia vulpina* from the other reference sites in and near the wilderness area should be analyzed at least every five years.
7. In order to further clarify the accumulation pattern for nickel and chromium in samples of *Rhizoplaca melanophthalma* at the basalt dike site; I also recommend that the basalt substrate be analyzed to determine nickel and chromium concentrations.

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APPENDIX A

LIST OF POLLUTION SENSITIVE INDICATOR SPECIES BY REFERENCE SITE:

Basalt Dike (Along State Road #274):

- Acarospora chlorophana* (sensitive to sulfur dioxide)
- Physcia dubia* (sensitive to intermediately sensitive to fluoride)
- Rhizoplaca melanophthalma* (sensitive to sulfur dioxide)

East Fork Bitterroot River Trail:

- Alectoria sarmentosa* (sensitive to ozone)
- Cladonia coniocraea* (intermediately sensitive to sulfur dioxide)

Cladonia fimbriata (sensitive to intermediately sensitive to sulfur dioxide)
Hypogymnia imshaugii (intermediately sensitive to ozone)
Leptochidium albociliatum (sensitive to intermediately sensitive to ozone)
Letharia columbiana (intermediately sensitive to ozone)
Letharia vulpina (intermediately sensitive to ozone)
Ochrolechia androgyna (sensitive to sulfur dioxide)
Parmelia saxatilis (intermediately sensitive to sulfur dioxide; sensitive to fluoride)
Parmelia sulcata (sensitive to intermediately sensitive to ozone; intermediately sensitive to sulfur dioxide; sensitive to fluoride)
Parmeliopsis ambigua (intermediately sensitive to sulfur dioxide)
Parmeliopsis hyperopta (intermediately sensitive to sulfur dioxide)
Peltigera canina (sensitive to ozone)
Peltigera collina (sensitive to ozone)
Phaeophyscia orbicularis (sensitive to ozone; intermediately sensitive to sulfur dioxide; sensitive to fluoride)
Physconia detersa (sensitive to intermediately sensitive to sulfur dioxide)
Plastimatia glauca (sensitive to ozone; intermediately sensitive to sulfur dioxide)
Rhizoplaca melanophthalma (sensitive to sulfur dioxide)
Tuckermannopsis chlorophylla (sensitive to sulfur dioxide)
Xanthoria fallax (sensitive to intermediately sensitive to sulfur dioxide; sensitive to nitrous oxides and PAN)

Goat Flat:

Acarospora chlorophana (sensitive to sulfur dioxide)
Letharia vulpina (intermediately sensitive to ozone)
Peltigera rufescens (sensitive to intermediately sensitive to ozone)
Pseudephebe minuscula (intermediately sensitive to ozone)
Pseudephebe pubescens (intermediately sensitive to ozone)
Rhizoplaca melanophthalma (sensitive to sulfur dioxide)

McCart Lookout Trail:

- Bryoria abbreviata* (sensitive to ozone)
- Bryoria fremontii* (sensitive to ozone)
- Cladonia coniocraea* (intermediately sensitive to sulfur dioxide)
- Cladonia fimbriata* (sensitive to intermediately sensitive to sulfur dioxide)
- Cladonia gracilis* (intermediately sensitive to sulfur dioxide)
- Letharia columbiana* (intermediately sensitive to ozone)
- Letharia vulpina* (intermediately sensitive to ozone)
- Parmeliopsis ambigua* (intermediately sensitive to sulfur dioxide)
- Parmeliopsis hyperopta* (intermediately sensitive to sulfur dioxide)
- Peltigera canina* (sensitive to ozone)
- Rhizoplaca chrysoleuca* (sensitive to sulfur dioxide, nitrous oxides, and PAN)
- Rhizoplaca melanophthalma* (sensitive to sulfur dioxide)
- Tuckermannopsis merrillii* (sensitive to intermediately sensitive to ozone)
- Xanthoria fallax* (sensitive to intermediately sensitive to sulfur dioxide; sensitive to nitrous oxides and PAN)

Middle Fork of Rock Creek:

- Alectoria sarmentosa* (sensitive to ozone)
- Bryoria abbreviata* (sensitive to ozone)
- Bryoria fremontii* (sensitive to ozone)
- Bryoria fuscescens* (intermediately sensitive to sulfur dioxide)
- Cladonia coniocraea* (intermediately sensitive to sulfur dioxide)
- Cladonia fimbriata* (sensitive to intermediately sensitive to sulfur dioxide)
- Cladonia gracilis* (intermediately sensitive to sulfur dioxide)
- Hypogymnia imshaugii* (intermediately sensitive to ozone)
- Hypogymnia physodes* (intermediately sensitive to sulfur dioxide)
- Letharia columbiana* (intermediately sensitive to ozone)
- Letharia vulpina* (intermediately sensitive to ozone)
- Ochrolechia androgyna* (sensitive to sulfur dioxide)
- Parmelia sulcata* (sensitive to intermediately sensitive to ozone; intermediately sensitive to sulfur dioxide; sensitive to fluoride)
- Parmeliopsis ambigua* (intermediately sensitive to sulfur dioxide)

Parmeliopsis hyperopta (intermediately sensitive to sulfur dioxide)
Peltigera canina (sensitive to ozone)
Plastismatia glauca (sensitive to ozone; intermediately sensitive to sulfur dioxide)
Tuckermannopsis chlorophylla (sensitive to sulfur dioxide)

Mt. Haggin Wildlife Management Area:

Alectoria sarmentosa (sensitive to ozone)
Cladonia fimbriata (sensitive to intermediately sensitive to sulfur dioxide)
Ochrolechia androgyna (sensitive to sulfur dioxide)

Pintler Creek Trailhead:

Alectoria sarmentosa (sensitive to ozone)
Bryoria abbreviata (sensitive to ozone)
Bryoria fremontii (sensitive to ozone)
Bryoria fuscescens (intermediately sensitive to sulfur dioxide)
Caloplaca cerina (sensitive to intermediately sensitive to sulfur dioxide)
Cladonia coniocraea (intermediately sensitive to sulfur dioxide)
Cladonia fimbriata (sensitive to intermediately sensitive to sulfur dioxide)
Cladonia gracilis (intermediately sensitive to sulfur dioxide)
Hypogymnia imshaugii (intermediately sensitive to ozone)
Hypogymnia physodes (intermediately sensitive to sulfur dioxide)
Lecanora saligna (intermediately sensitive to sulfur dioxide)
Letharia vulpina (intermediately sensitive to ozone)
Ochrolechia androgyna (sensitive to sulfur dioxide)
Parmelia saxatilis (intermediately sensitive to sulfur dioxide; sensitive to fluoride)
Parmelia sulcata (sensitive to intermediately sensitive to ozone; intermediately sensitive to sulfur dioxide; sensitive to fluoride)
Parmeliopsis ambigua (intermediately sensitive to sulfur dioxide)
Parmeliopsis hyperopta (intermediately sensitive to sulfur dioxide)
Peltigera canina (sensitive to ozone)
Peltigera rufescens (sensitive to intermediately sensitive to ozone)

Physcia caesia (intermediately sensitive to sulfur dioxide)
Platismatia glauca (sensitive to ozone; intermediately sensitive to sulfur dioxide)
Pseudephebe minuscula (intermediately sensitive to ozone)
Pseudephebe pubescens (intermediately sensitive to ozone)
Rhizoplaca melanophthalma (sensitive to sulfur dioxide)
Tuckermannopsis chlorophylla (sensitive to sulfur dioxide)
Tuckermannopsis merrillii (sensitive to intermediately sensitive to ozone)

Ten Mile Creek (Along U.S.F.S. Road #2483):

Cladonia coniocraea (intermediately sensitive to sulfur dioxide)
Cladonia fimbriata (sensitive to intermediately sensitive to sulfur dioxide)

Vicinity of Fourmile Basin Lakes:

Bryoria fremontii (sensitive to ozone)
Cladonia fimbriata (sensitive to intermediately sensitive to sulfur dioxide)
Cladonia gracilis (intermediately sensitive to sulfur dioxide)
Hypocenomyce scalaris (intermediately sensitive to sulfur dioxide)
Letharia columbiana (intermediately sensitive to ozone)
Letharia vulpina (intermediately sensitive to ozone)
Ochrolechia androgyna (sensitive to sulfur dioxide)
Parmelia saxatilis (intermediately sensitive to sulfur dioxide; sensitive to fluoride)
Parmeliopsis ambigua (intermediately sensitive to sulfur dioxide)
Parmeliopsis hyperopta (intermediately sensitive to sulfur dioxide)
Peltigera canina (sensitive to ozone)
Physcia caesia (intermediately sensitive to sulfur dioxide)
Pseudephebe pubescens (intermediately sensitive to ozone)
Rhizocarpon geographicum (sensitive to fluoride)
Rhizoplaca melanophthalma (sensitive to sulfur dioxide)