‘Lichens of the Columbia River Basin

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Lichens:

I. Introduction:

Lichens are fungi growing in harmony with algae or cyanobacteria (blue-green algae). They grow together symbiotically forming a plant with its own distinct characteristics. Lichens absorb nutrients and moisture for growth from rain water and atmospheric gases. The fungal component absorbs moisture and nutrients and pass them onto the algae. These fungal greenhouses provide for the growth of algae in sites where they could not exist without the protection and support of the fungi.

Lichens grow in all habitats in the Colombia Basin. They are prevalent in both forest and rangelands cover types. Most of the forest lichens grow on trees. They do not feed on the trees, a tree is simply a place to live: Lichens can grow in places that other organisms cannot. In this way lichens fill the empty places in the forest where they do not have to compete with other vegetation. They increase the diversity, biomass, and texture in the forest canopy. They form a biological chinking in the forest with a wide variety of species, shapes and forms.

Lichen species occur in very specific habitats yet as a group the frequency of wetting and drying is critical to their existence. How frequently the lichens are moistened and how fast they dry up is critical to their survival and vigor. Changes in the humidity and temperatures within a forest canopy are reflected in a shift in the species of lichens present. As a forest progresses in succession there is a similar fixed pattern of lichen succession. Some of the lichens enter the

forests only after the trees have matured and created a proper substrate and canopy climate. It takes over 200 years for these "late successional lichens" to enter the forest (Lescia et al. 1991, McCune 1991). Some species of lichens are only found in forests that have remained in a continuous forested condition longer than the individual trees that make up that forest (500+ years), (Goward 1992, Rose 1976). In England, a large number of lichen species have been determined which are indicators of woodland age and environmental continuity (Broad 1989, Rose & Wolseley 1984).

Dispersal and Reproduction

Many lichens are dispersal limited (Esseen et al. 1981, Hale 1974). Most forest lichens reproduce by asexual reproductive structures rather than by sexual spores. These asexual structures are small fragments composed of both fungal and algae partners. These fragments are larger than spores and, therefore, disperse only short distances.

However, in the dry interior forest cover types, with little maritime climatic influence, in some of the Columbia Basin physiographic provinces the black tree lichen, *Bryoria* spp., is common and reinvades burned or disturbed stands readily. These lichens can survive forest fires, from these areas the black tree lichen recolonizes the forests that regrow in these sites. This genus of lichen is the major food source for the small mammals in the forested ecosystems of the Columbia Basin (Hayward and Rosentreter 1994).

Lichens are primary producers accumulating carbohydrates. A large number of secondary chemicals are produced within the lichen thallus. About 200 chemical compounds have been recognized to date; phenolic acids, depisides, depsidones, etc. they are termed lichen acids. Over 60 chemicals are known to occur only in lichens (Broad 1989).

The role of lichens in forest and rangeland ecosystems:

Forests:

Lichens are primary producers in the forest. Their biomass and nutrients contribute to the forest litter and duff, enriching the soil and increasing soil moisture holding capacity. Arboreal lichens capture fog, retaining moisture within the forest. Many lichens fix atmospheric nitrogen (Denison 1973). The alectorioid lichens are a major food source for animals such as flying squirrels, red-backed voles, and woodrats (Maser, Trappe and Nussbaum 1978). They are also a secondary food source in the winter for deer, and elk. They provide habitat and food for canopy-dwelling invertebrates (Gerson & Seaward 1977). Birds and small mammals use lichens as nest building material and camouflage (Broad 1989). Air quality can be accessed by evaluating the types of lichens present. Lichens are sensitive to SO, and other gases and are efficient accumulators of heavy metals (McCune 1988). They may contain medicinal values yet undiscovered.

-lichen/ fungi/ small mammal/ owl connection.

In the winter months when snow covers the ground the small mammals that normally eat fungi, switch to arboreal lichens as a food source (Hayward and Rosentreter 1994; Maser, Trappe, and Nussbaum 1978). These small mammals are the prey for forest owls. Maintenance of the proper

edible species of arboreal lichens is critical to the small mammal populations during the critical winter stress period.

Rangelands:

In rangelands lichens are part of a group of plants growing together and referred to as microbiotic crusts (see the rangelands section). These microbiotic plants include mosses, lichens and algae that grow directly on the soil. They occur among and beneath the scattered clumps of shrubs and perennial grasses. These plants cushion the impact of rain drops and increase soil moisture infiltration. Once moisture is in the soil, microbiotic plants act as an organic mulch by shading, cooling, and decreasing evaporation of soil moisture. Thus, sites with well developed microbiotic plants will retain more soil moisture within the soil profile.

Some of the algae in the soil and within the lichens are blue-green algae (cyanobacteria). These algae will fix atmospheric nitrogen and change it into a form (nitrate) that other plants can utilize. Nitrogen is the second most limiting factor after moisture in the sagebrush steppe. Therefore, the additional input of nitrogen by the algae and lichens is important for them and for their neighbors. These lower plants lack a waxy epidermis for retaining the nitrogen, so they are simply "leaked out" into the surrounding soil.

Studies have shown that fewer seeds germinate in areas covered by microbiotic plants, but more total plants become established compared to bare soil sites (Harper and Marble 1988). Without the microbiotic plants, the bare soil sites are harsh, with greater temperature extremes and less

moisture retention. Microbiotic plants may also serve as a check for invasion by exotic annuals. For example, cheatgrass will invade bare soil sites much more densely than it will a site colonized by microbiotic plants.

During much of the summer and fall, the sagebrush steppe is dry and susceptible to extreme wind erosion. Where colonies of microbiotic plants are intact, they protect and hold the soil in place, reducing this wind erosion. When they are absent, much valuable topsoil is lost.

When microbiotic plants are moist, they are pliable and resistant to livestock trampling. However, once the soil surface dries, trampling will break apart the plant's network of microscopic, root-like rhyzoids, severely damaging the crust they form. Historically, it appears that the native ungulates, such as deer and pronghom antelope, stayed in the higher country until winter weather drove them down to the sagebrush steppe. With moist or frozen surface soils, the animals could walk on the microbiotic plants with minimal impact. In spring, the animals moved to higher elevations before the soils completely dried, again with minimal impact. Season of use for livestock should include consideration of microbiotic plants and soil moisture, for protection of the plants, and ultimately, for protection of the watershed.

Legal Status

In the Columbia Basin only one lichen, ***Texosporium sancti-jacobi***, is currently federally listed as a candidate species under the ESA.

II. METHODS

Five contract reports on the functional role and distribution of lichens in the Columbia River Basin were prepared about the lichens in this region. The titles and authors of the contracted reports are as follows:

1) Eastside Lichen Report for Washington and Oregon by Dr. Bruce Ryan (1994);

2) Lichens of the Yellowstone Ecosystem by Dr. Sharon Eversman (1994);

3) Lichen Species Groups in the Columbia River Basin, Ecosystem Functions and Indicator Values by Dr. Bruce McCune (1994);

4) Microbiotic Soil Crusts in Sagebrush Habitats of Southern Idaho by Julie Kaltenecker and Dr. Marcia Wicklow-Howard (1994); and

5) The Biogeography and Ecology of Species in the Lichen Genus *Cladonia* in the Columbia River Basin by Dr. Samuel Hammer (1994).

Information from these contracts, follow up interviews with the contractors, and a review of the scientific literature facilitated the construction of a data base on the ecosystem functions, threats, and biology of lichens in the Columbia River Basin. Most of the nomenclature follows Egan (1987) and changes by Egan (1989, 1990, 1991) as well as other taxonomic revisions made by Hammer (1993, 1995). Seven hundred and thirty-six lichen species were documented in herbarium collections for the Basin (Table 1).

III. RESULTS

The 736 lichen species were divided into 40 functional groups based on their ecological relationships. The lichens are treated as functional species groups rather than as individual species due to the large number of species in the Basin, and as a means of emphasizing their ecological function. The species groups are further sorted into the four major substrates on which the lichens occur. The four major substrate groups are: 1) dead organic matter; 2) corticate and decorticate wood; 3) rock; and 4) soil. The species groups are listed with their ecosystem function in Table 2. Table 3 lists all 736 species and their relative abundance rating sorted by functional sorted by functional group. The indicator value of the functional lichen species groups are listed in Table 4 and trend and threats to the species groups are listed in Table 5.

The names and definitions of the 40 functional groups arranged by the four major substrates are as follows:

1) DEAD ORGANIC MATTER

1.a. Charred snag:

These are small lichens adapted to grow on charred snags and are most frequent on these specialized substrates.

1 .b. Fencepost lichens:

Lichens that most often occur on old wooden fenceposts in rangeland and dry forest habitats.

1.c. Oceanic log:

These species occur where the climate is oceanically influenced. An oceanic climate is characterized by mild wet winters and some moisture during the rest of the year. This artificial grouping of lichens occurs on solid downed logs also known as coarse woody debris (CWD). Moisture-loving trees such as grand fir, western red cedar, and larch are indicators of an oceanic influence. These trees are specific to oceanic habitats.

1.d. Rotten log and tree base:

This artificial grouping of lichens occurs only on late decay class (rotten) logs or at tree bases. These lichens are a diverse group that contains some distinctive chemistry within the lichens themselves.

1.e. Moss and detritus binders:

This group of lichens grows on the dead or live moss and detritus covering the forest floor.

These species bind together much of the loose organic matter on the forest floor.

2) EPIPHYTES

2.a. N-fixing epiphytes:

These are the large nitrogen-fixing lichen epiphytes on the trees and shrubs.

2.b. N-fixing riparian:

Nitrogen-fixing lichen epiphytes on trees and shrubs that are generally restricted to the riparian areas.

2.c. Riparian:

Lichen epiphytes generally restricted to riparian area trees and shrubs that do not fix nitrogen.

The fog and open water of the riparian areas appear critical to the distribution of these species.

They are generally large pendant or flat leaf-like species that become locally abundant and obvious in the trees.

2.d. Aspen specialist:

This one species, Arthonia patellulata, is restricted to the bark of aspen trees.

2.e. Excess nitrogen indicators:

This group of lichens increases when there is excess nitrogen in the environment. This excess nitrogen generally originates from livestock concentrates (i.e., feedlots), dusty roads, or chemical fertilizers.

2.f Urban pollution-tolerant:

This lichen species, Candelaria concolor, increases in chemically polluted urban areas.

2.g. Forage:

These are the large pendant lichens that are epiphytic on the branches of trees and shrubs, primarily in the genera Alectoria, Bryoria, and Usnea. They provide critical winter food for ungulates and some small mammals. These species are also used as a food source by Native Americans.

2.h. Oceanic forage:

Similar to “forage lichens” but they only occur where the climate is oceanically influenced. They provide critical winter food for ungulates and some small mammals.

2.i. Oceanic leaf:

This group of lichens is flat and leaf-like in shape but only occurs where the climate is oceanically influenced.

2.j. Oceanic tree crusts:

This artificial group of crustose species occurs on the base and lower portions of live and dead tree boles where the climate is oceanically influenced. The occasionally occur on the twigs of trees and may contain some distinctive chemicals.

2. k. Oceanic fruticose:

This group of lichens occurs on trees and shrubs and appears very "shrubby" due to its highly branched growth form. These lichens only occur where the climate is oceanically influenced.

2.1. Fruticose tree lichens:

This group of epiphytic lichens contains the fruticose (shrubby) lichens that are not included in the forage lichens group and are not restricted to an oceanically influenced climate.

2.m. Pin:

These small to diminutive lichens look like small pins arising from a bed of green algae (thick or thin thallus). Many different genera comprise this group that occurs in microsites sheltered from direct precipitation, yet they require a very humid atmosphere. This group of lichens is very substrate and species specific. These lichens often occur on the sheltered side of large leaning trees.

2.n. Tree crusts:

These are small microlichens (crustose) that are most common on trunks and twigs of trees.

2.0. Leaf lichens:

This group of lichens is comprised of epiphytic lichens on trees and shrubs. These lichens are short, tufted or flat, leaf-like in shape and general appearance. They are a diverse group composed of several genera that occur in the same ecological niche in many different types of forest and shrub communities.

2.p. Bog lichens:

These is only one species within the Basin in this group, Cetraria sepincola, which is restricted to trees or shrubs that occur in bogs.

3) ROCKS

3 .a. Aquatic rocks:

This group of lichens is truly aquatic and will die if desiccated. These species increase surface area and create conditions enhancing aquatic invertebrate populations. They are good indicators of water quality and constancy of flow levels.

3.b. Calcareous rock indicators:

This group of lichens is restricted to calcareous rocks.

3 .c. Metal-rich rock indicators:

These is only one species within the Basin in this group, Tremolecia atrata, which is restricted to metal-rich rocks.

3 .d. Sheltered ledges and overhangs:

This group of lichens occurs in either narrow sheltered ledges or larger, slightly overhanging rock faces or cliffs. These lichens are a diverse group composed of several genera that occur in the same ecological niche and include the umbilicate lichens that are used to produce a purple-colored dye.

3 .e. Seepage rocks:

This group of lichens occurs where there is seasonal seepage over rocks. The sites stay moist for long periods of time. These lichens have cyanobacteria within them and appear as tufted or spreading black filaments.

3.f. N-fixing rock:

This group of nitrogen-fixing lichens occurs on rocks outside of seepage areas.

3 .g. Tundra rock:

This group of lichens occurs on rocks and is restricted to tundra habitats.

3. h. Rock crusts:

This group of microlichens (crustose) includes 129 species that occur on rock. They do not fix nitrogen nor are they restricted to calcareous or metal-rich rocks or to tundra habitats.

3.i. Rock mats and cushions:

This group of fruticose (shrubby) lichens occurs in dense log-growing mats and cushions on the ground. These lichens are often referred to as "reindeer lichens," since reindeer and other ungulates forage on them in the winter. In this region, these lichens are restricted to cold, wet sites over shallow soil or rock.

3.j. Oceanic rock:

This group of lichens occurs on rock and is restricted to areas where the climate is oceanically influenced.

3 .k. Rock macrolichens:

This artificial group of large-sized (macro) lichens (52 species) occurs on unspecialized rock types and is fairly common and widespread.

4) SOIL

4.a. N-fixing soil lichens:

This group of 21 black-colored, gelatinous-textured lichen species occurs on the soil surface and fixes nitrogen. These species are widespread and common in arid rangelands and on shallow soil sites throughout the region.

4.b. Calcareous steppe indicators:

This group of soil-occurring lichens is restricted to calcareous sites. Many of these species are bright yellow to orange-colored and are easily noticed.

4.c. Steppe soil crusts:

This group of soil-occurring microlichens is restricted to steppe communities and is not restricted to calcareous sites, nor does it fix nitrogen.

4.d. Pioneer soil stabilizers:

This group of lichens is an early pioneer species that stabilizes soil surfaces. These lichens can multiply rapidly and disperse long distances, often producing specialized vegetative reproductive structures. They can occur in disturbed sites in many different vegetation types.

4. e. Tundra forage lichens:

This group of erect lichens are fairly broad and leaf-like in appearance and occur on the soil surface. These lichens are all in the genus Cetraria, are utilized by ungulates for forage, and are restricted to tundra climatic conditions.

4.f Tundra sod builders:

This group of lichens occurs directly on the soil. These species add to the organic matter, build sod, and cover the soil surface. They are restricted to tundra climatic conditions.

4.g. Vagrant ground lichens:

This group of lichens is composed of species in the Aspicilia, Dermatocarpon, Rhizoplaca, and Xanthoparmelia genera. These lichens are free-living with no attachments to a substrate. They roll around on the soil surface and among the vegetation like miniature tumbleweeds in rangeland habitats.

4.h. Soil:

This group of lichens occurs on the soil. The genus Peltigera, that looks like living leaves on the forest floor, makes up the bulk of this group. These lichens are a relatively fast-growing species and protect the forest floor from erosion.

TV. Disscussion:

The lichen flora of the forests in this Eastside Forests region is dominated by arboreal black forage lichens in the genus Bryoria also commonly known as goat's beard or witches hair (Tables 1, 2, 4). These forests are adapted for fire, although the natural fire frequency has been greatly altered by humans through fire suppression management (Table 5). Fire suppression has resulted in dense forests of a different composition than the open, park-like conditions maintained by natural fires. Dense closed stands of trees contain fewer lichens than open stands of trees. Uneven aged management of stands would provide for the legacy (seed trees) of lichens to recolonize regenerated trees.

The native american Indians used these lichens extensively for food, often mixing it with their pemmican (Turner 1990). These black tree lichens also serve as a major food source for flying squirrels, red-backed voles and many invertebrates (Maser et al. 1985), and for deer and elk in the winter (Hodgman and Boyer 1985; Table 4).

These black tree lichens appear to be fairly good at dispersing into areas that have been disturbed by fires. Lichens in the region appear good at dispersing into areas that have been disturbed by fire. Natural forest bums generally leasve behind clumps of unburned trees with intact lichens and even portions of lichens on burned trees and snags. These legacy stocks, which are typically absent from large clearcuts and dense forest stands, serve to "seed" the regenerating forests. Site treatments such as piling and slash burning also decrease the remnant lichen legacy in a stand (personal observation R. Rosentreter). Many stands are surface treated to get thick regeneration rather than encouraging natural regeneration. These treatments and other surface treatments, and overstocking with artificial plantings produce dense forests that do not favor the growth of forage lichens. Such timber practices have probably decreased the abundance of the forage lichens, but the application of silvicultural innovations such as uneven-age forest management and retention of clumps of legacy trees will help improve the potenial for lichen regeneration.

The President's forest plan (Thomas et al. 1993) addressed this topic for the forests west of the Cascades, but there have been no such scientific studies on this topic in this region. Basic lichen floristic surveys and practical applied research into maintaining lichens in managed forests of this region are sorely needed. The Columbia River Assessment Project addresses these species and

some possible solutions at the community level. Additional work will need to be done to elucidate effective strategies for maintaining and restoring lichens in harvested and burned portions of these forests.

Rangelands of the Columbia Basin

This region has a rather low diversity of lichens, but they are a major component of the ecosystem (Tables 1, 2). In many habitats, their surface area cover is 30 percent or greater (Wicklow-Howard and Kaltenucker 1994). In the sagebrush steppe and the Columbia River grasslands, a mixture of bryophytes, lichens, and cyanobacteria collectively referred to as "microbiotic crusts" fill the interspaces between the shrubs and bunchgrasses. This association of species is similar in many other parts of the world, including Asia and Australia (West 1990). These microbiotic crusts vary slightly by region but have many similar species that are well adapted for these habitat conditions.

The nitrogen-fixing lichens and cyanobacteria that are part of the biotic crust are important in improving soil fertility, and microbiotic crustsin general increase soil stability, influence water infiltration, and may improve seed germination for various plant species (West 1990; St. Clair and Johansen 1993; Table 2). Intact microbiotic crusts may also interfere with the establishment of exotic plants such as cheatgrass. Relative to many other groups of microorganisms, microbiotic crusts have been well studied (St. Clair and Johnsen 1993). Nonetheless, details of the ecological role of microbiotic crust species as soil stabilizers and nitrogen fiexers are still being elucidated (Belnap 1994); the role of microbiotic crusts as potential barriers to the establishment of cheatgrass needs to be studied further and correlated with patterns of land-use, disturbance histories, and soil properties.

Many of these lichens species are widespread globally (West 1990), yet the area they now cover

in the United States has been greatly reduced compared to historic times (McCune and Rosentreter 1992). The major threats to survival of mirobiotic crusts in this region include: invasion of exotic annual grasses and resulting increases in fire frequency; the conversion of rangelands to agriculture and suburban developments; and livestock trampling (West 1990; St. Clair and Johansen 1993; Table 5). Increased fire frequency (>40 times) due to introduction of cheatgrass has led to dramatic changes in ecosystem sturcture (Whisenant 1990). Much of the shrub steppe has been converted to a dense, closed stand of annual exotic grasses to the exclusion of crust communities. Areas still containing shrubs and microbiotic crusts can be grazed when the soil is moist with little harm to the biotic crusts @Vi&low-Howard and Kaltenucker 1994), but many areas have been severely impacted by livestock trampling in the dry season (Belnap 1990; St. Clair and Johansen 1993). One microbiotic crust species, the woven-spored lichen, (Texosporium sancti-jacobi), is restricted to two general localities within the region. It is the only lichen species in the Pacific Northwest considered a candidate for listing as threatened or endangered by the federal goverment (McCune and Rosentreter 1992).

A second important group, the tumbleweed or vagrant ground lichens (Tables 1, 2), grow, persist, and reproduce without attachment to a substrate (Rosentreter 1993). They are declining due to loss and fragmentation of habitat, and herbivory by grazing domestic sheep(Table 5). Their tumbleweed dispersal habit requires continuous habitat; numerous roads with drainage ditches collect lichens, leaflitter, and deep snow, which leads to conditions that eventually kill the lichens. Such threats combined with widespresd habitat conversion to exotic annual grasses have led to the extirpated of vagrant ground lichen from many parts of the region. No appropriate areas are

managed to provide for the continual existence of these vagrant lichens. In fact, some species still remain unnamed by science (Ryan University of Arizona pers. comm.). Applied research on the management of these lichens and their role as forage for native pronghom antelope is needed (Thomas and Rosentreter 199 1).

V. Inventory and Research Needs:

Lichens are an important component of forests and rangelands of the Columbia Basin. Yet basic knowledge about these species and their interacts are limited. Therefore, baseline inventories to document lichen species presence, abundance, biomass, habitat requirements, and geographic distribution is needed. Inventory data needs to be incorporated into the general biological inventory efforts, computerized and mapped. Standardized methods for the sampling of forest epiphytes needs to be developed. This data should be verified with voucher specimens deposited in recognized regional herbaria. From this information identification guides and annotated catalogs for lichens in each physiographic region should be developed.

Status survey reviews should be conducted for the rare lichen species. This information needs to be shared with the State Heritage Programs in each State to compliment information from private and State lands. Conservation strategy plans should be developed for these rare species to conserve and enhance their populations.

Successional studies should be conducted of lichens, including their establishment, diversity and abundance in stands of different ages and different plant associations, substrates, and vertical succession. Conduct basic and applied research to determine lichens dispersal patterns by species, groups of species, by forest types, and recovery after fires.

Develop monitoring and research plans to evaluate the effects of forest and rangeland management practices on lichens. Monitor the impacts from management activities including timber harvesting, silvicultural practices, grazing, and recreation. For example, what species of lichens are retained in retention trees by topographic position, tree symmetry, crown type, or aggregation of the retention trees? What is the advantage of selecting leave trees that contain a diversity of lichen species and do these lichens on retention trees act as centers of dispersal for those species?

Determine nitrogen fixation rates of the lichens in the microbiotic crusts in different rangeland cover types. Determine the quantity and nutrient content of lichen litter-fall in the forest cover types. Develop a research project to address the role of lichen, through-fall and litter-fall in the nutrient cycling and biomass production of the various types and ages of forests. Conduct research into the role of small mammals (flying squirrels, and boreal red-backed voles) eating lichen litter-fall and its role in the trophic dynamics of small mammals and their predators such as, the boreal owls. Conduct research into the species preferences of lichens for nest building by flying squirrels. Conduct research on the role of lichens as habitat and food for forest invertebrates.

Develop an integrated, regional air quality monitoring program using lichens as biological indicators of forest health, including impacts on lichen species and trends in lichen populations. Alectorioid and cyanolichens are especially sensitive to air pollution, and should be monitored to detect impacts to viability from a decline in air quality.

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all the other references are in FEMAT. terrestrial chapter. IV-190.Disscussion:

Table 2. Ecosystem functions of species groups of lichens. A "Y" in a column indicates "Yes, one or more members of a given species group perform the indicated function.

Notes:

N fix = Nitrogen fixation via cyanobacteria
Forage = Use as forage by ungulates
Nest = Commonly used as nesting materials by bids ad small mammals
soil stab = Contributes to stabilization of the soil surface
Rock weath = Contribues to rock weathering and soil formation
Lower albedo = Significantly lowers albedo of exposed rock or soil, as in high mountain areas and arid ecosystems
Microhabitat = Provides microhabitat ad food for invertebrates

Species group	No. spp	Ecosystem Functions						
		N fix	For-age	Nest	Soil stab	Rock weath	Lower albedo	Micro-habitat
DEAD ORGANIC SUBSTRATES								
charred snag lichens	3							Y
fencepost lichens	3							Y
oceanic log lichens	6							Y
rotten log and tree base	11							Y
moss & detritus binders	38				Y			Y
EPIPHYTES								
N-fixing epiphytes	8	Y						Y
N-fixing riparian	7	Y						Y
riparian	10							Y
aspen specialists	1							Y
excess nitrogen indicators	2							Y
urban pollution-tolerant	1							Y
forage	10		Y	Y				Y
oceanic forage lichens	3		Y	Y				Y
oceanic leaf lichens	14							Y
oceanic tree crusts	20							Y
oceanic fruticose	6		Y	Y				Y
fruticose tree lichens	14		Y	Y				Y
pin	9							Y
tree crusts	81							Y

leaf lichens	40							Y
bog lichens	1							Y
ROCK LICHENS								
aquatic rocks	16					Y		Y
calcareous rock indicators	40					Y	Y	Y
metal-rich rock indicators	1					Y	Y	Y
sheltered ledges & overhangs	12					Y		Y
seepage rocks	3	Y				Y	Y	Y
N-fixing rock lichens	21	Y				Y		Y
tundra rock lichens	17					Y	Y	Y
rock crusts	129					Y	Y	Y
rock mats and cushions	20		Y			Y	Y	Y
oceanic rock lichens	4					Y	Y	Y
rock macrolichens	52					Y	Y	Y
SOIL LICHENS								
N-fixing soil lichens	21	Y			Y			Y
calcareous steppe indicators	9				Y		Y	Y
steppe soil crusts	17				Y		Y	Y
pioneer soil stabilizers	6				Y			Y
tundra forage lichens	4		Y		Y			Y
tundra sod builders	37	Y			Y			Y
vagrant ground lichens	8		Y					Y
soil lichens	18				Y			Y

3

Table 1. Lichen species (count = 735) in the Columbia River Basin east of the Cascade crest, and their membership in species groups. A "1" under "rare" indicates that the species is rare within this region.
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Species	Rare	Species Group
Acarospora bullata	0	rock crusts
Acarospora chlorophana	0	rock crusts
Acarospora fuscata	0	rock crusts
Acarospora glaucocarpa	0	calcareous rock indicator
Acarospora murorum	1	rock crusts
Acarospora schleicheri	0	steppe soil crusts
Acarospora smarag. v. lesd	0	rock crusts
Acarospora smaragdula	0	rock crusts
Acarospora strigata	0	calcareous rock indicator
Acarospora thamnina	0	rock crusts
Acarospora veronensis	0	rock crusts
Actinogyra polyrrhiza	1	rock macrolichens
Adelolecia pilati	1	rock crusts
Ahtiana sphaerosporella	0	leaf lichens
Alectoria imshaugii	0	fruticose tree lichens
Alectoria nigricans	1	tundra sod builders
Alectoria sarmentosa	0	oceanic forage lichens
Alectoria vancouverensis	1	oceanic forage lichens
Alectoria vexillifera	0	tundra sod builders
Allantoparmelia alpicola	0	rock macrolichens
Anaptychia ulotrichodes	0	calcareous rock indicator
Arctoparmelia incurva	1	rock macrolichens
Arctoparmelia subcentrifuga	1	rock macrolichens
Arthonia glebosa	0	steppe soil crusts
Arthonia patellulata	0	aspen specialists
Arthonia radiata	1	tree crusts
Arthroraphis citrinella	0	moss & detritus binders
Aspicilia "convoluta"	0	rock crusts
Aspicilia "glebosa"	0	rock crusts
Aspicilia aliena	0	rock crusts

Aspicilia alphoplaca	0	rock crusts
Aspicilia aquatica	0	aquatic rocks
Aspicilia arctica	1	rock crusts
Aspicilia caesiocinerea	0	rock crusts
Aspicilia calcarea	0	rock crusts
Aspicilia candida	0	rock crusts
Aspicilia cinerea	0	rock crusts
Aspicilia desertorum	0	rock crusts
Aspicilia desertorum	0	rock crusts
Aspicilia fruticulosa	1	vagrant ground lichens
Aspicilia hispida	0	vagrant ground lichens
Aspicilia mastrucata	0	rock crusts
Aspicilia praeradiosa	0	rock crusts
Aspicilia reptans	0	steppe soil crusts
Aspicilia supertegens	0	rock crusts
Bacidia akompsa	0	tree crusts
Bacidia bagliettoana	0	moss & detritus binders
Bacidia beckhausii	1	tree crusts
Bacidia hegetschweileri	1	tree crusts
Bacidia herrei	1	tree crusts
Bacidia idahoensis	0	oceanic tree crusts
Bacidia sabulaetorum	0	moss & detritus binders
Bacidia subincompta	0	tree crusts
Baeomyces rufus	0	soil lichens
Bellemerea alpina	0	rock crusts
Bellemerea cinereorufescens	0	rock crusts
Bellemerea diamarta	1	rock crusts
Biatora albohyalina	0	tree crusts
Biatora sphaeroides	0	moss & detritus binders
Biatora vernalis	0	moss & detritus binders
Brodoa oroarctica	0	tundra rock lichens
Bryonora castanea	0	tundra sod builders
Bryonora pruinosa	0	tundra sod builders
Bryoria abbreviata	0	fruticose tree lichens

Bryoria capillaris	0	forage
Bryoria chalybeiformis	0	tundra sod builders
Bryoria fremontii	0	forage
Bryoria friabilis	0	oceanic forage lichens
Bryoria fuscescens	0	forage
Bryoria glabra	0	forage
Bryoria implexa	1	forage
Bryoria lanestris	0	forage
Bryoria nadvornikiana	1	forage
Bryoria oregana	0	forage
Bryoria pseudofuscescens	0	forage
Bryoria simplicior	1	fruticose tree lichens
Bryoria subdivergens	1	tundra sod builders
Bryoria vrangiana	0	forage
Buellia badia	0	moss & detritus binders
Buellia disciformis	0	tree crusts
Buellia elegans	0	calcareous steppe indicat
Buellia erubescens	0	tree crusts
Buellia geophila	0	moss & detritus binders
Buellia papillata	0	moss & detritus binders
Buellia punctata	0	tree crusts
Buellia retrovertens	0	rock crusts
Buellia zahlbruckneri	0	tree crusts
Calicium adaequatum	0	pin
Calicium corynellum	1	sheltered ledges & overha
Calicium trabinellum	0	pin
Calicium viride	0	pin
Caloplaca albovariegata	0	rock crusts
Caloplaca approximata	0	rock crusts
Caloplaca arenaria	0	rock crusts
Caloplaca atroalba	0	calcareous rock indicator
Caloplaca atrosanguinea	0	oceanic tree crusts
Caloplaca cerina	0	tree crusts
Caloplaca chrysophthalma	0	tree crusts

Caloplaca cinnabarina	0	rock crusts
Caloplaca cinnamomea	0	tundra sod builders
Caloplaca citrina	0	rock crusts
Caloplaca cladodes	0	calcareous rock indicator
Caloplaca decipiens	0	calcareous rock indicator
Caloplaca diphyodes	0	aquatic rocks
Caloplaca epithallina	0	rock crusts
Caloplaca feracissima ?	0	calcareous rock indicator
Caloplaca flavorubescens	0	tree crusts
Caloplaca flavovirescens	0	rock crusts
Caloplaca fraudans	0	rock crusts
Caloplaca holocarpa	0	tree crusts
Caloplaca invadens	0	rock crusts
Caloplaca jungermanniae	0	moss & detritus binders
Caloplaca lactea	0	calcareous rock indicator
Caloplaca lamprocheila	0	rock crusts
Caloplaca lithophila	0	calcareous rock indicator
Caloplaca modesta	0	rock crusts
Caloplaca saxicola	0	rock crusts
Caloplaca sinapisperma	1	tundra sod builders
Caloplaca stillicidiorum	0	moss & detritus binders
Caloplaca subpyraceela	0	moss & detritus binders
Caloplaca tiroliensis	0	moss & detritus binders
Caloplaca tominii	0	calcareous steppe indicat
Caloplaca trachyphylla	0	calcareous rock indicator
Caloplaca ulmorum	0	tree crusts
Caloplaca variabilis	0	calcareous rock indicator
Candelaria concolor	0	urban pollution-tolerant
Candelariella aurella	0	calcareous rock indicator
Candelariella efflorescens	0	tree crusts
Candelariella rosulans	0	rock crusts
Candelariella terrigena	0	soil lichens
Candelariella vitellina	0	rock crusts
Carbonea vitellinaria	0	rock crusts

Carbonea vorticosa	0	rock crusts
Catapyrenium cinereum	0	tundra sod builders
Catapyrenium congestum	1	steppe soil crusts
Catapyrenium daedaleum	1	tundra sod builders
Catapyrenium lachneum	0	soil lichens
Catapyrenium lachneum v oleosum	0	soil lichens
Catapyrenium lacinulatum	0	steppe soil crusts
Catapyrenium norvegicum	1	sheltered ledges & overha
Catapyrenium rufescens	0	steppe soil crusts
Catapyrenium squamulosum	0	steppe soil crusts
Catillaria sphaeroides	0	tree crusts
Cetraria canadensis	0	leaf lichens
Cetraria chlorophylla	0	leaf lichens
Cetraria cucullata	0	tundra forage lichens
Cetraria eric. ssp retic.	0	tundra forage lichens
Cetraria hepatizon	0	rock macrolichens
Cetraria idahoensis	0	leaf lichens
Cetraria islandica	0	tundra forage lichens
Cetraria merrillii	0	leaf lichens
Cetraria nivalis	0	tundra forage lichens
Cetraria orbata	0	leaf lichens
Cetraria pallidula	0	leaf lichens
Cetraria pinastri	0	leaf lichens
Cetraria platyphylla	0	leaf lichens
Cetraria sepincola	1	bog lichens
Cetraria tilesii	0	tundra sod builders
Chaenotheca furfuracea	0	sheltered ledges & overha
Chaenotheca laevigata	0	pin
Chaenotheca stemonea	0	pin
Chaenotheca subroscida	0	pin
Chromatochlamys muscorum	0	steppe soil crusts
Chrysothrix candelaris	0	tree crusts
Chrysothrix chlorina	0	sheltered ledges & overha
Cladina arbuscula	1	rock mats and cushions

Cladina mitis	1	rock mats and cushions
Cladina rangiferina	1	rock mats and cushions
Cladonia anderegii	1	moss and detritus binders
Cladonia asahinae	1	soil lichens
Cladonia bacillaris	0	rotten log and tree base
Cladonia bellidiflora	1	soil lichen
Cladonia borealis	0	rock mats and cushions
Cladonia botrytes	1	rotten log and tree base
Cladonia cariosa	0	pioneer soil stabilizers
Cladonia carneola	0	rotten log and tree base
Cladonia cenotea	0	rotten log and tree base
Cladonia cervicornis	0	rock mats and cushions
Cladonia cervicornis verticillata	0	rock mats and cushions
Cladonia chlorophaea	0	soil lichens
Cladonia coccifera	1	soil lichens
Cladonia coniocraea	0	rotten log and tree base
Cladonia conista	1	rotten log and tree base
Cladonia cornuta	0	rock mats and cushions
Cladonia cornuta groenlandica	1	soil lichen
Cladonia crispata	1	rock mats and cushions
Cladonia dahliana	0	soil lichens
Cladonia deformis	0	rock mats and cushions
Cladonia digitata	1	rotten log and tree base
Cladonia dimorpha	1	soil lichen
Cladonia ecmocyna	0	rock mats and cushions
Cladonia fimbriata	0	soil lichens
Cladonia firma	0	soil lichens
Cladonia gracilis	0	rock mats and cushions
Cladonia imbricarica	1	rock mats and cushions
Cladonia luteoalba	1	soil lichens
Cladonia macilenta	1	rotten log and tree base
Cladonia macrophyllodes	0	soil lichens
Cladonia merochlorophaea	0	oceanic log lichens
Cladonia multiformis	0	rock mats and cushions

Cladonia norvegica	1	rotten log and tree base
Cladonia ochrochlora	0	rotten log and tree base
Cladonia phyllophora	0	rock mats and cushions
Cladonia pleurota	0	rock mats and cushions
Cladonia pocillum	0	soil lichens
Cladonia prolifica	1	soil lichens
Cladonia pyxidata	0	soil lichens
Cladonia rei	1	soil lichens
Cladonia scabriuscula	1	soil lichens
Cladonia singularis	1	soil lichens
Cladonia squamosa	0	oceanic log lichens
Cladonia subsquamosa	1	oceanic log lichens
Cladonia subulata	0	rotten log and tree base
Cladonia sulphurina	0	rotten log and tree base
Cladonia transcendens	1	oceanic log lichens
Cladonia umbricola	0	oceanic log lichens
Cladonia uncialis	1	rock mats and cushions
Cladonia verruculosa	0	soil lichens
Cliostomum corrugatum	1	oceanic tree crusts
Coelocaulon aculeatum	0	rock mats and cushions
Coelocaulon muricatum	0	tundra sod builders
Collema ceraniscum	1	tundra sod builders
Collema coccophorum	0	steppe soil crusts
Collema crispum	0	N-fixing rock lichens
Collema curtisporum	1	riparian
Collema furfuraceum	0	N-fixing rock lichens
Collema fuscovirens	0	N-fixing rock lichens
Collema polycarpon	0	N-fixing rock lichens
Collema tenax	0	N-fixing soil lichens
Collema undulatum	1	N-fixing rock lichens
Cornicularia normoerica	1	tundra rock lichens
Cyphelium inquinans	0	tree crusts
Cyphelium karelicum	1	tree crusts
Cyphelium pinicola	0	fencepost lichens

Cyphelium tigillare	0	fencepost lichens
Cystocoleus ebeneus	0	seepage rocks
Dactylina madreporiformis	1	tundra sod builders
Dactylina ramulosa	1	tundra sod builders
Dermatocarpon intestiniformis	0	tundra rock lichens
Dermatocarpon luridum	0	aquatic rocks
Dermatocarpon miniatum	0	calcareous rock indicator
Dermatocarpon moulinsii	0	calcareous rock indicator
Dermatocarpon reticulatum	0	rock macrolichens
Dermatocarpon rivulorum	0	aquatic rocks
Dermatocarpon vellereum	0	calcareous rock indicator
Dimelaena oreina	0	rock crusts
Dimelaena thysanota	0	rock crusts
Dimerella pineti	0	rotten log and tree base
Diploschistes albescens	0	rock crusts
Diploschistes muscorum	0	moss & detritus binders
Diploschistes scruposus	0	rock crusts
Diplotomma epipolium	1	rock crusts
Diplotomma penichrum	0	oceanic tree crusts
Diplotomma sp. nov.	1	sheltered ledges & overha
Endocarpon pulvinatum	0	rock crusts
Endocarpon pusillum	0	steppe soil crusts
Endocarpon tortuosum	0	rock crusts
Ephebe hispidula	1	riparian
Ephebe lanata	1	seepage rocks
Ephebe perspinulosa	1	riparian
Ephebe solida	1	seepage rocks
Euopsis pulvinata	1	rock crusts
Evernia divaricata	1	fruticose tree lichens
Evernia mesomorpha	1	fruticose tree lichens
Evernia prunastri	0	oceanic leaf lichens
Farnoldia jurana	0	calcareous rock indicator
Flavopunctelia flaventior	1	riparian
Fulgensia bracteata	0	calcareous steppe indicat

Fulgensia desertorum	0	calcareous steppe indicat
Fuscidea praeruptorum	1	rock crusts
Glaucomaria rupicola	0	rock crusts
Glaucomaria rupicola v sor	0	sheltered ledges & overha
Gonohymenia nigritella	0	calcareous rock indicator
Graphis scripta	1	oceanic tree crusts
Gyalecta foveolaris	1	tundra soil
Heppia lutosa	0	steppe soil crusts
Hydrothyria venosa	1	aquatic rocks
Hypocenomyce castaneocine	0	charred snag lichens
Hypocenomyce friesii	1	charred snag lichens
Hypocenomyce scalaris	0	charred snag lichens
Hypogymnia apinnata	1	oceanic leaf lichens
Hypogymnia austerodes	0	leaf lichens
Hypogymnia bitteri	1	leaf lichens
Hypogymnia enteromorpha	1	oceanic leaf lichens
Hypogymnia imshaugii	0	leaf lichens
Hypogymnia inactiva	1	oceanic leaf lichens
Hypogymnia metaphysodes	0	oceanic leaf lichens
Hypogymnia montana	0	leaf lichens
Hypogymnia occidentalis	0	oceanic leaf lichens
Hypogymnia physodes	0	leaf lichens
Hypogymnia rugosa	1	oceanic leaf lichens
Hypogymnia tubulosa	0	leaf lichens
Icmadophila ericetorum	0	oceanic log lichens
Imshaugia aleurites	0	leaf lichens
Japewia subaurifera	1	oceanic tree crusts
Japewia tornoensis	1	oceanic tree crusts
Koerberia sonomensis	0	rock macrolichens
Lecania fuscella	0	tree crusts
Lecania koerberiana	0	tree crusts
Lecanora argopholis	0	rock crusts
Lecanora atrosulphurea	1	tundra rock lichens
Lecanora beringii	0	tundra sod builders

Lecanora cadubriae	0	tree crusts
Lecanora caesiorubella var sax.	0	rock crusts
Lecanora carpinea	0	oceanic tree crusts
Lecanora cascadensis	0	rock crusts
Lecanora cenisea	0	rock crusts
Lecanora chlarona	0	tree crusts
Lecanora chlarotera	0	tree crusts
Lecanora circumborealis	0	tree crusts
Lecanora crenulata	0	calcareous rock indicator
Lecanora demissa	0	rock crusts
Lecanora dispersa	0	calcareous rock indicator
Lecanora epibryon	0	tundra sod builders
Lecanora flowersiana	0	rock crusts
Lecanora fuscescens	0	tree crusts
Lecanora garovaglii	0	rock crusts
Lecanora hageni	0	tree crusts
Lecanora hybocarba	1	tree crusts
Lecanora hypoptoides	0	tree crusts
Lecanora impudens	0	tree crusts
Lecanora intricata	0	rock crusts
Lecanora marginata	0	rock crusts
Lecanora melanaspis	1	aquatic rocks
Lecanora microfusca	1	tundra sod builders
Lecanora muralis	0	rock crusts
Lecanora nevadensis	0	rock crusts
Lecanora occidentalis	0	rock crusts
Lecanora pacifica	1	oceanic tree crusts
Lecanora palanderi	0	tree crusts
Lecanora phaedrophthalma	0	rock crusts
Lecanora piniperda	0	tree crusts
Lecanora polytropa	0	rock crusts
Lecanora populicola	0	tree crusts
Lecanora pringlei	0	sheltered ledges & overha
Lecanora pseudomellea	0	rock crusts

Lecanora pulicaris	0	tree crusts
Lecanora reagens	0	soil lichens
Lecanora rugosella	0	tree crusts
Lecanora rupicola v. sorediata	0	sheltered ledges & overha
Lecanora salicicola	0	tree crusts
Lecanora sierrae	0	rock crusts
Lecanora symmicta	0	tree crusts
Lecanora thomsonii	0	rock crusts
Lecanora umbrosa	0	rock crusts
Lecanora varia	0	tree crusts
Lecanora zosterae	0	moss & detritus binders
Lecidea atrobrunnea	0	rock crusts
Lecidea atromarginata	0	rock crusts
Lecidea auriculata	0	rock crusts
Lecidea berengeriana	0	moss & detritus binders
Lecidea cinnabarina	0	tree crusts
Lecidea confluens	0	rock crusts
Lecidea dolodes	1	tree crusts
Lecidea elabens	0	tree crusts
Lecidea fuscoatra	0	rock crusts
Lecidea lactea	0	rock crusts
Lecidea lapicida f ochracea	0	rock crusts
Lecidea lapicida	0	rock crusts
Lecidea lithophila	0	rock crusts
Lecidea mannii	0	rock crusts
Lecidea marginata	0	rock crusts
Lecidea myriocarpoides	0	tree crusts
Lecidea paddensis	0	tree crusts
Lecidea plana	0	rock crusts
Lecidea plebeja	0	tree crusts
Lecidea protobacina	0	rock crusts
Lecidea sp. nov.	1	steppe soil crusts
Lecidea syncarpa	0	rock crusts
Lecidea tessellata	0	rock crusts

Lecidea turgidula	0	tree crusts
Lecidea umbonata	0	rock crusts
Lecidella 'riparia'	0	aquatic rocks
Lecidella anomaloides	0	rock crusts
Lecidella carpathica	0	rock crusts
Lecidella elaeochroma	0	tree crusts
Lecidella euphorea	0	tree crusts
Lecidella goniophila	0	rock crusts
Lecidella inamoena	0	rock crusts
Lecidella incongruella	0	rock crusts
Lecidella patavina	0	calcareous rock indicator
Lecidella stigmatea	0	rock crusts
Lecidella wulfenii	0	tundra sod builders
Lecidoma demissum	0	tundra sod builders
Lempholemma myriococcum	1	sheltered ledges & overha
Lempholemma radiatum	1	soil lichens
Lepraria finkii	0	rock crusts
Lepraria neglecta	0	tundra sod builders
Leprocaulon microscopicum	0	moss & detritus binders
Leprocaulon subalbicans	0	moss & detritus binders
Leproloma cacuminum	0	tundra sod builders
Leptochidium albociliatum	0	N-fixing rock lichens
Leptogium corniculatum	1	rock mats and cushions
Leptogium cyanescens	1	N-fixing rock lichens
Leptogium gelatinosum	0	N-fixing rock lichens
Leptogium hirsutum	1	N-fixing riparian
Leptogium intermedium	1	moss & detritus binders
Leptogium lichenoides	0	moss & detritus binders
Leptogium rivale	1	aquatic rocks
Leptogium saturninum	0	N-fixing riparian
Leptogium tenuissimum	1	soil lichens
Leptogium teretiusculum	1	N-fixing riparian
Letharia columbiana	0	fruticose tree lichens
Letharia vulpina	0	fruticose tree lichens

Lichenothelia scopularia	0	moss & detritus binders
Lobaria hallii	1	N-fixing riparian
Lobaria linita	1	N-fixing rock lichens
Lobaria oregana	1	N-fixing epiphytes
Lobaria pulmonaria	0	N-fixing epiphytes
Lobaria scrobiculata	1	N-fixing rock lichens
Lopadium disciforme	0	oceanic tree crusts
Massalongia carnosa	0	moss & detritus binders
Megaspora verrucosa	0	moss & detritus binders
Melanelia disjuncta	0	rock macrolichens
Melanelia elegantula	0	leaf lichens
Melanelia exasperatula	0	leaf lichens
Melanelia fuliginosa	0	leaf lichens
Melanelia glabra	1	leaf lichens
Melanelia infumata	0	rock macrolichens
Melanelia multispora	0	oceanic leaf lichens
Melanelia panniformis	0	rock macrolichens
Melanelia sorediosa	0	rock macrolichens
Melanelia stygia	0	rock macrolichens
Melanelia subargentifera	0	rock macrolichens
Melanelia subaurifera	0	leaf lichens
Melanelia subelegantula	0	oceanic leaf lichens
Melanelia subolivacea	0	leaf lichens
Melanelia tominii	0	rock macrolichens
Micarea assimilata	1	tundra sod builders
Micarea melaena	1	tundra sod builders
Micarea prasina	1	tree crusts
Micarea sylvicola	1	rock crusts
Miriquidica garovaglii	1	rock crusts
Miriquidica leucophaea	1	rock crusts
Multiclavula coxynoides	0	soil lichens
Multiclavula vernalis	0	soil lichens
Mycobilimbia berengeriana	0	moss & detritus binders
Mycobilimbia hypnorum	0	moss & detritus binders

Mycobilimbia lobulata	0	moss & detritus binders
Mycobilimbia microcarpa	1	tundra sod builders
Mycobilimbia obscurata	0	moss & detritus binders
Mycobilimbia sabuletorum	0	moss & detritus binders
Mycoblastus sanguinarius	0	tree crusts
Neofuscelia loxodes	0	rock macrolichens
Neofuscelia subhosseana	0	rock macrolichens
Neofuscelia verruculifera	0	rock macrolichens
Nephroma bellum	0	N-fixing riparian
Nephroma helveticum	0	N-fixing riparian
Nephroma parile	0	N-fixing rock lichens
Nephroma resupinatum	0	N-fixing riparian
Normandina pulchella	0	tree crusts
Ochrolechia androg. v saxorum	0	rock crusts
Ochrolechia androgyna	0	tree crusts
Ochrolechia cf. mexicana	0	tree crusts
Ochrolechia frigida	0	tundra sod builders
Ochrolechia gowardii	0	tree crusts
Ochrolechia juvenalis	0	tree crusts
Ochrolechia montana	0	tree crusts
Ochrolechia oregonensis	1	tree crusts
Ochrolechia szatalaensis	0	tree crusts
Ochrolechia upsaliensis	0	moss & detritus binders
Ophioparma lapponicum	0	rock crusts
Pannaria cyanolepra	0	N-fixing soil lichens
Pannaria leucophaea	0	rock macrolichens
Pannaria leucostictoides	1	N-fixing epiphytes
Pannaria mediterranea	1	N-fixing epiphytes
Pannaria pezizoides	0	moss & detritus binders
Pannaria praetermissa	0	N-fixing rock lichens
Pannaria saubinetii	1	N-fixing epiphytes
Parmelia fraudans	1	rock macrolichens
Parmelia hygrophila	0	oceanic leaf lichens
Parmelia omphalodes	0	tundra sod builders

Parmelia saxatilis	0	rock macrolichens
Parmelia sulcata	0	leaf lichens
Parmeliella triptophylla	1	N-fixing epiphytes
Parmeliopsis ambigua	0	leaf lichens
Parmeliopsis hyperopta	0	leaf lichens
Peltigera aphthosa	0	N-fixing soil lichens
Peltigera britannica	0	N-fixing soil lichens
Peltigera canina	0	N-fixing soil lichens
Peltigera cinnamomea	0	N-fixing soil lichens
Peltigera collina	0	N-fixing rock lichens
Peltigera didactyla	0	pioneer soil stabilizers
Peltigera elisabethae	0	N-fixing rock lichens
Peltigera horizontalis	0	N-fixing rock lichens
Peltigera kristinssonii	0	N-fixing soil lichens
Peltigera lepidophora	0	tundra sod builders
Peltigera leucophlebia	0	N-fixing soil lichens
Peltigera malacea	0	N-fixing rock lichens
Peltigera membranacea	0	N-fixing soil lichens
Peltigera neckeri	0	N-fixing soil lichens
Peltigera neopolydactyla	1	N-fixing soil lichens
Peltigera pacifica	1	N-fixing soil lichens
Peltigera polydactyla	0	N-fixing soil lichens
Peltigera ponojensis	0	N-fixing soil lichens
Peltigera praetextata	0	N-fixing soil lichens
Peltigera rufescens	0	N-fixing soil lichens
Peltigera venosa	0	N-fixing soil lichens
Peltula euploca	1	N-fixing rock lichens
Pertusaria amara	0	tree crusts
Pertusaria borealis	0	tree crusts
Pertusaria leucostoma	1	oceanic tree crusts
Pertusaria ophthalmiza	0	tree crusts
Pertusaria pupillaris	1	rock crusts
Pertusaria sommerfeltii	1	oceanic tree crusts
Pertusaria stenhammari	1	oceanic tree crusts

Pertusaria subambigens	1	oceanic tree crusts
Pertusaria suboculata	1	oceanic tree crusts
Phaeocalicium compressulum	0	pin
Phaeocalicium populneum	0	pin
Phaeophyscia ciliata	1	leaf lichens
Phaeophyscia constipata	0	rock macrolichens
Phaeophyscia decolor	0	rock macrolichens
Phaeophyscia hirsuta	0	leaf lichens
Phaeophyscia kairamoi	1	rock macrolichens
Phaeophyscia nigricans	0	leaf lichens
Phaeophyscia orbicularis	0	leaf lichens
Phaeophyscia sciastra	0	rock macrolichens
Phaeorrhiza nimbosa	0	tundra sod builders
Phaeorrhiza sareptana	0	steppe soil crusts
Phlyctis argena	0	oceanic tree crusts
Phlyctis speirea	1	tree crusts
Phylliscum demangeonii	0	aquatic rocks
Physcia adscendens	0	excess nitrogen indicator
Physcia aipolia	0	leaf lichens
Physcia biziana	0	rock macrolichens
Physcia caesia	0	rock macrolichens
Physcia dimidiata	0	rock macrolichens
Physcia dubia	0	rock macrolichens
Physcia magnussonii	0	rock macrolichens
Physcia phaea	0	rock macrolichens
Physcia semipinnata	1	riparian
Physcia stellaris	0	leaf lichens
Physcia tenella	0	leaf lichens
Physciella chloantha	0	leaf lichens
Physciella melanchra	0	leaf lichens
Physconia americana	0	oceanic leaf lichens
Physconia detersa	0	leaf lichens
Physconia enteroxantha	0	leaf lichens
Physconia isidiigera	0	leaf lichens

Physconia muscigena	0	moss & detritus binders
Physconia perisidiosa	0	leaf lichens
Physconia thomsonii	0	calcareous rock indicator
Pilophorus acicularis	1	N-fixing rock lichens
Pilophorus clavatus	1	N-fixing rock lichens
Placopsis gelida	1	N-fixing rock lichens
Placynthiella icmalea	0	pioneer soil stabilizers
Placynthiella oligotropha	0	pioneer soil stabilizers
Placynthiella uliginosa	0	pioneer soil stabilizers
Placynthium nigrum	0	calcareous rock indicator
Platismatia glauca	0	leaf lichens
Platismatia herrei	1	oceanic leaf lichens
Platismatia norvegica	1	oceanic leaf lichens
Platismatia stenophylla	1	oceanic leaf lichens
Polyblastia cruenta	1	aquatic rocks
Polychidium muscicola	0	moss & detritus binders
Polysporina simplex	0	rock crusts
Porpidia crustulata	0	rock crusts
Porpidia glaucophaea	0	rock crusts
Porpidia macrocarpa	0	rock crusts
Porpidia thomsonii	0	rock crusts
Protoblastenia rupestris	0	calcareous rock indicator
Protoparmelia badia	0	rock crusts
Protoparmelia cupreobadia	1	tundra rock lichens
Protoparmelia ochrococca	0	oceanic tree crusts
Pseudephebe minuscula	0	tundra rock lichens
Pseudephebe pubescens	0	rock macrolichens
Pseudocyphellaria anomala	1	N-fixing epiphytes
Pseudocyphellaria anthras	1	N-fixing epiphytes
Psora cerebriformis	0	calcareous steppe indicat
Psora decipiens	0	calcareous steppe indicat
Psora globifera	0	steppe soil crusts
Psora himalayana	0	calcareous steppe indicat
Psora montana	0	steppe soil crusts

Psora nipponica	0	rock crusts
Psora tuckermanii	0	calcareous steppe indicat
Psoroma hypnorum	0	moss & detritus binders
Psorotichia schaereri	1	N-fixing rock lichens
Ramalina dilacerata	0	riparian
Ramalina farinacea	1	riparian
Ramalina obtusata	1	riparian
Ramalina pollinaria	1	riparian
Ramalina thrausta	1	riparian
Rhizocarpon badioatrum	0	aquatic rocks
Rhizocarpon bolanderi	0	rock crusts
Rhizocarpon concentricum	0	aquatic rocks
Rhizocarpon copelandii	1	tundra rock lichens
Rhizocarpon disporum	0	rock crusts
Rhizocarpon effiguratum	0	rock crusts
Rhizocarpon geminatum	0	rock crusts
Rhizocarpon geographicum	0	rock crusts
Rhizocarpon grande	0	rock crusts
Rhizocarpon hochstetteri	1	tundra rock lichens
Rhizocarpon lecanorinum	0	rock crusts
Rhizocarpon macrosporum	0	rock crusts
Rhizocarpon polycarpum	0	tundra rock lichens
Rhizocarpon pusillum	0	rock crusts
Rhizocarpon riparium	0	rock crusts
Rhizocarpon sphaerosporum	0	rock crusts
Rhizocarpon superficiale	0	tundra rock lichens
Rhizoplaca chrysoleuca	0	rock macrolichens
Rhizoplaca haydenii	1	vagrant ground lichens
Rhizoplaca idahoensis	1	vagrant ground lichens
Rhizoplaca melanophthalma	0	rock macrolichens
Rhizoplaca peltata	0	calcareous rock indicator
Rimularia insularis	0	rock crusts
Rinodina archaea	0	tundra sod builders
Rinodina bischofii	0	rock crusts

Rinodina castanomelodes	0	calcareous rock indicator
Rinodina colobina	0	tree crusts
Rinodina confragosa	0	rock crusts
Rinodina convexula	0	tree crusts
Rinodina corticola	0	tree crusts
Rinodina dakotensis	0	tree crusts
Rinodina disjuncta	1	oceanic tree crusts
Rinodina exigua	0	tree crusts
Rinodina glauca	1	tree crusts
Rinodina ligniaria	0	tree crusts
Rinodina lignicola	0	tree crusts
Rinodina marysvillensis	0	tree crusts
Rinodina milvina	0	rock crusts
Rinodina mniaraea	0	tundra sod builders
Rinodina mucronatula	0	tree crusts
Rinodina oregana	0	oceanic tree crusts
Rinodina pyrina	0	tree crusts
Rinodina roscida	0	tundra sod builders
Rinodina septentrionalis	0	oceanic tree crusts
Rinodina trevisani	0	tree crusts
Rinodina turfacea	0	tundra sod builders
Rinodina zwackhiana	0	calcareous rock indicator
Rinodinella lobulata	0	tree crusts
Sarcogyne privigna	0	calcareous rock indicator
Sarcogyne pruinosa	0	calcareous rock indicator
Sarcogyne regularis	0	calcareous rock indicator
Sarcosagium campestre	0	moss & detritus binders
Schaereria tenebrosa	1	tundra rock lichens
Solorina bispora	1	tundra soil
Solorina crocea	0	N-fixing soil lichens
Solorina saccata	1	tundra soil
Solorina spongiosa	1	N-fixing soil lichens
Sphaerophorus globosus	1	oceanic fruticose
Sporastatia polyspora	1	tundra rock lichens

Sporastatia testudinea	0	tundra rock lichens
Staurothele areolata	0	rock crusts
Staurothele clopimoides	0	rock crusts
Staurothele drummondii	0	rock crusts
Staurothele fissa	0	aquatic rocks
Staurothele monicae	0	calcareous rock indicator
Stenocybe pullata	0	pin
Stereocaulon alpinum	0	N-fixing soil lichens
Stereocaulon glareosum	0	N-fixing soil lichens
Stereocaulon grande	1	rock mats and cushions
Stereocaulon paschale	1	rock mats and cushions
Stereocaulon sasakii v. tom.	0	rock mats and cushions
Stereocaulon sterile	0	rock macrolichens
Stereocaulon tomentosum	0	rock mats and cushions
Strangospora moriformis	0	tree crusts
Teloschistes contortuplicatus	0	calcareous rock indicator
Tephromela aglaea	1	rock crusts
Tephromela armeniaca	0	tundra rock lichens
Tephromela atra	0	rock crusts
Texosporium sancti-jacobi	1	steppe soil crusts
Thamnolia subuliformis	0	tundra sod builders
Thelocarpon sp.	0	moss & detritus binders
Thelomma ocellatum	0	fencepost lichens
Thrombium epigaeum	0	pioneer soil stabilizers
Toninia candida	0	calcareous rock indicator
Toninia ruginosa	0	moss & detritus binders
Toninia sedifolia	0	calcareous steppe indicat
Toninia squalida	0	moss & detritus binders
Trapelia involuta	1	rock crusts
Trapeliopsis flexuosa	0	tree crusts
Trapeliopsis granulosa	0	moss & detritus binders
Trapeliopsis sp. nov.	0	steppe soil crusts
Trapeliopsis wallrothii	0	moss & detritus binders
Tremolecia atrata	0	metal-rich rock indicator

Umbilicaria americana	0	sheltered ledges & overha
Umbilicaria angulata	1	oceanic rock lichens
Umbilicaria **arctica**	0	rock macrolichens
Umbilicaria **decussatus**	0	rock **macrolichens**
Umbilicaria **deusta**	0	rock macrolichens
Umbilicaria **havaasii**	1	oceanic rock lichens
Umbilicaria hyperborea	0	rock macrolichens
Umbilicaria **krascheninnik**	0	tundra rock lichens
Umbilicaria lambii	1	oceanic rock lichens
Umbilicaria phaea	0	rock macrolichens
Umbilicaria polyphylla	0	rock macrolichens
Umbilicaria polyrrhiza	1	oceanic rock lichens
Umbilicaria torrefacta	0	rock macrolichens
Umbilicaria vellea	0	sheltered ledges & overha
Umbilicaria virginis	0	tundra rock lichens
Usnea cavernosa	1	fruticose tree lichens
Usnea diplotypus	0	fruticose tree lichens
Usnea filipendula	0	oceanic fruticose
Usnea **glabrata**	1	oceanic fruticose
Usnea **glabrescens**	0	liuticose tree lichens
Usnea **hirta**	0	fiuticose tree lichens
Usnea **lapponica**	0	fruticose tree lichens
Usnea **plicata agg.**	0	oceanic fiuticose
Usnea scabrata . .	0	oceanic fruticose
Usnea scabrata ssp nylan.	0	oceanic fruticose
Usnea **sphacelata**	1	tundra rock lichens
Usnea subfloridana	0	fiuticose tree lichens
Usnea substerilis	0	fruticose tree lichens
Varicellaria rhodocarpa	1	tree crusts
Verrucaria aethiobola	0	aquatic rocks
Venucaria calciseda	0	calcareous **rock** indicator
Verrucaria calkinsiana	0	rock crusts
Verrucaria compacta	0	**calcareous** rock indicator
Venucaria **fuscella**	0	calcareous rock indicator

Verrucaria glaucovirens	0	calcareous rock indicator
Verrucaria hydrela	0	aquatic rocks
Verrucaria margacea	0	aquatic rocks
Verrucaria muralis	0	calcareous rock indicator
Verrucaria viridula	0	calcareous rock indicator
Verrucaria zamenhofiana	0	calcareous rock indicator
Xanthoparmelia angustiphyllya	1	rock macrolichens
Xanthoparmelia chlorochroa	0	vagrant ground lichens
Xanthoparmelia coloradoensis	0	rock macrolichens
Xanthoparmelia cumberlandia	0	rock macrolichens
Xanthoparmelia hypopsila	0	rock macrolichens
Xanthoparmelia lineola	0	rock macrolichens
Xanthoparmelia mexicana	0	rock macrolichens
Xanthoparmelia montanensis	1	rock macrolichens
Xanthoparmelia neochlorochroa	1	vagrant ground lichens
Xanthoparmelia norchlorochroa	1	vagrant ground lichens
Xanthoparmelia plittii	0	rock macrolichens
Xanthoparmelia subdecipiens	0	rock macrolichens
Xanthoparmelia wyomingica	0	vagrant ground lichens
Xanthoria candelaria	0	sheltered ledges & overha
Xanthoria elegans	0	rock macrolichens
Xanthoria fallax	0	excess nitrogen indicator
Xanthoria lobulata	0	calcareous rock indicator
Xanthoria polycarpa	0	leaf lichens
Xanthoria sorediata	0	rock macrolichens
Xylographa abietina	0	tree crusts

Table 4. Indicator values of functional groups of lichen species.

Notes:

Air **qual** = Indicator of air quality (either good or reduced, depending on the species)
Mend-rich rock = Indicates high content of metals in rock
High N = Indicates excess concentrations of biologically active nitrogen, as in agricultural areas with heavy fertilizer use, as well as natural **locally** high concentrations (as on bird perches **and** below **packrat middens)**
$CaC0_3$ = Indicates high concentration of free calcium carbonate, either in soil or rock
Old growth = Indicates long period without **major** disturbance. Applied here both to forests and to steppe ecosystems
Plow level = **Bands** of occurrence indicates water flow levels, perennial seepage, or **lake** levels

Species group	No. spp	Indicator Values: Air Qual	Metal-rich rock	High N	CaC03	Old growth	Flow level
DEAD ORGAN-K SUBSTRATES							
charred snag lichens	3	Y				Y	
fencepost lichens	3	Y		Y			
oceanic log lichens	6	Y				Y	
rotten log and tree base	11	Y				Y	
moss & detritus binders	38	Y				Y	
EPIPHYTES							
N-fixing epiphytes	8	Y				Y	
N-fixing riparian	7	Y				Y	
riparian	10	Y				Y	
aspen specialists	1	Y					
excess nitrogen indicators	2	Y		Y			
urban pollution-tolerant	1	Y		Y			
forage	10	Y				Y	
oceanic forage lichens	3	Y				Y	
oceanic leaf lichens	14	Y				Y	
oceanic tree crusts	20	Y				Y	
oceanic fruticose	6	Y				Y	
fruticose tree lichens	14	Y				Y	

pin	9	Y				Y	
tree crusts	81	Y				Y	
leaf lichens	40	Y					
bog lichens	1	Y					
ROCK LICHENS							
aquatic rocks	16						Y
calcareous rock indicators	40	Y			Y		
metal-rich rock indicators	1	Y	Y				
sheltered ledges & overhangs	12	Y					
seepage rocks	3	Y					Y
N-fixing rock lichens	21	Y					
tundra rock lichens	17	Y					
rock crusts	129	Y	Y	Y	Y		
rock mats and cushions	20	Y					
oceanic rock lichens	4	Y					
rock macrolichens	53	Y		Y			
SOIL LICHENS							
N-fixing soil lichens	21	Y					
calcareous steppe indicators	9	Y			Y	Y	
steppe soil crusts	17	Y				Y	
pioneer soil stabilizers	6	Y					
tundra forage lichens	4	Y					
tundra sod builders	37	Y			Y		
vagrant ground lichens	8	Y			Y		
soil lichens	18	Y					

Table 5. Functional lichen groups rated by trend and listing of the treats to the species in these groups.

Note: Trend are: 1-rare, 2-decreasing, 3-stable, 4-increasing ratings for the viability of these species groups throughout the Columbia River Basin. Threats are as follows: E- Exotic/ weed invasion, F- Change in fire regime, G- Livestock grazing, H- Change in hydrologic regime, M- Mining, R- Recreation, T- Timber harvest.

Species group	No. spp	Trend	Threats
DEAD ORGANIC SUBSTRATES			
charred snag lichens	3	3	F,T
fencepost lichens	3	3	
oceanic log lichens	6	2	F,T
rotten log and tree base	11	2	F,T
moss & detritus binders	38	3	E,G,M,T
EPIPHYTES			
N-fixing epiphytes	8	1	T
N-fixing riparian	7	2	R,T
riparian	10	2	R,T
aspen specialists	1	3	R,T
excess nitrogen indicators	2	4	
urban pollution-tolerant	1	4	
forage	10	2	R,T
oceanic forage lichens	3	2	R,T
oceanic leaf lichens	14	2	R,T
oceanic tree crusts	20	2	R,T
oceanic fruticose	6	2	R,T
fruticose tree lichens	14	2	R,T
pin	9	2	F,R,T
tree crusts	81	2	R,T
leaf lichens	40	3	
bog lichens	1	1	H,T
ROCK LICHENS			
aquatic rocks	16	2	G,H,M,T

calcareous rock indicators	40	3	
metal-rich rock indicators	1	3	
sheltered ledges & overhangs	12	3	
seepage rocks	3	3	
N-fixing rock lichens	21	3	
tundra rock lichens	17	3	
rock crusts	129	3	
rock mats and cushions	20	2	F,G,M,R,T
oceanic rock lichens	4	3	
rock macrolichens	52	3	
SOIL LICHENS			
N-fixing soil lichens	21	2	E,F,G,R
calcareous steppe indicators	9	2	E,F,G,R
steppe soil crusts	17	2	E,F,G,R
pioneer soil stabilizers	6	4	
tundra forage lichens	4	3	
tundra sod builders	37	3	
vagrant ground lichens	8	2	E,F,G,R
soil lichens	18	2	E,F,G,R