Natural History and Management Considerations for Northwest Forest Plan Survey and Manage Lichens

Based on Information as of the Year 2000

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Preface

The Northwest Forest Plan, adopted in 1994, is currently the guiding document for management of federal lands within the range of the northern spotted owl; i.e., western Oregon, Washington, and parts of northern California (USDA Forest Service and USDI Bureau of Land Management 1994a, b, c). The Survey and Manage Standard and Guideline of the Northwest Forest Plan provides mitigation for late-successional and old-growth associated species whose persistence might not be assured by other components of the Northwest Forest Plan.

Management recommendations were released in 2000 to provide managers and resource specialists of the Forest Service and the Bureau of Land Management with current information about the natural histories, status and threats, management considerations, and information needs for 29 of the lichen taxa included in the Survey and Manage Standard and Guideline. The primary intent of that document was to provide assistance in the management of known sites of Survey and Manage lichen species as directed in the Northwest Forest Plan.

The Survey and Manage Standard and Guideline was revised in 2001 (USDA Forest Service and USDI Bureau of Land Management 2001). This amendment to the Northwest Forest Plan directs that new information about Survey and Manage species be evaluated on an annual basis by teams of taxa specialists and managers. During the Annual Species Review, the status of species within the Survey and Manage Program is adjusted if new information shows that a higher or lower degree of mitigation is needed. Species may also be dropped from the Standard and Guideline or moved to other programs if new information shows that they do not meet the criteria for inclusion in Survey and Manage; likewise, new species that do meet the inclusion criteria may be added.

Although not all of the species presented in this document are still included in the Survey and Manage Standards and Guideline, the information that was assembled regarding taxonomy, nomenclature, morphology, chemistry, reproductive biology, ecological roles, range and distribution, habitat requirements, viability considerations, and threats to the species may continue to be of value to managers, conservationists, interpreters, and lichenologists. New information for some species is available elsewhere (Derr *et al*. 2003a; Derr *et al*. 2003b; Derr *et al*. 2003c), and updates the information presented here. Except for nomenclatural updates to *Buellia*, *Dendriscocaulon, Pannaria,* and *Pseudocyphellaria*, and removal of incorrect locations of *Byroria spiralifera and Pannaria rubiginosa*, the species accounts remain essentially unchanged from the official version released electronically on March 2, 2000, under file codes FS 1920/2600 and BLM 1630/1736-PFP (BLM-OR9311) and entitled, "Survey and Manage Management Recommend-ations – Lichens." The original document is accessible in electronic form at the url: http://web.or.blm.gov/ForPlan/MR-Lichen/index.htm

Acknowledgements

The Lichen Management Recommendations were prepared with the input and review of many individuals, whom we gratefully acknowledge. We thank all students of lichens, both historical and present, who have contributed to our knowledge of their distribution, habitats, and ecology and have generously shared this information through their herbarium collctions, publications, and personal communications. Stewards of the following herbaria kindly provided specimens and assistance: California Academy of Science (CAS), Duke University (DUKE), Humboldt State University (HSC), Marion Ownbey Herbarium, Washington State University, Pullman (WS), Oregon State University (OSC), the private herbaria of Bruce McCune and John Davis, San Francisco State University (SFSU), U.S. Herbarium, Smithsonian Institution (US), University of British Columbia (UBC), University of California, Berkeley (UCB), University of Washington (WTU), Western Washington University (WWB), and the Siuslaw NF Herbarium.

Many lichenologists and other scientists provided specific technical advice and input during the preparation of the Management Recommendations. They include Suraj Ahuja, Shelly Benson, Mark Boyll, Irwin Brodo, Doug Glavich, Katie Glew, Trevor Goward, Jan Henderson, Marusa Herrera-Campos, Bruce McCune, Peter Neitlich, Fred Rhoades, Jim Riley, Roger Rosentreter, Abbey Rosso, Sylvia and Steve Sharnoff, Steve Sillett, Larry St. Clair, Tør Tonsberg, and Barbara Williams. In addition, Katie Glew, Fred Rhoades, Bruce Ryan, Agnel Dawson, Cheryl McCaffrey, and John Davis reviewed earlier drafts. Mark Boyll prepared early versions of these documents.

A technical review team was comprised of individuals selected to represent the perspectives of management and field implementation. An expert on the intent of Record of Decision and the Lichen Taxa Lead also participated in this process. The team included Lisa Hoover, Brad Keller, John Bacho, Robin Lesher, and Nancy Fredricks. Sheila Martinson and Norm Gartley served as review coordinators. Martha Brooks was the initial technical editor. Robin Lesher and Nancy Fredricks completed the final editing for consistency of content. Annie Ingersoll, Gail Saunders and Laurie Ystad helped to prepare this text edition from the electronic files of March, 2000.

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Bryoria pseudocapillaris

SUMMARY

Species: *Bryoria pseudocapillaris* Brodo & D. Hawksw.
Taxonomic Group: Lichens (Rare Oceanic-Influenced)
ROD Components: 1, 3

Other Management Status: Oregon Natural Heritage Program List 2 (taxa that are threatened with extirpation or presumed to be extirpated from the State of Oregon). Natural Heritage Networks Rank Global Rank G2? (rank of G2 is uncertain, but is defined as imperiled because of rarity or because other factors demonstrably make it very vulnerable to extinction (extirpation), typically with 6-20 occurrences). State Rank S1 (critically imperiled because of extreme rarity or because it is somehow especially vulnerable to extinction or extirpation, typically with 5 or fewer occurrences) (Oregon Natural Heritage Program 1998). BLM Assessment Status (USDI Bureau of Land Management 1998).

Range: The world-wide distribution of this endemic lichen consists of seven coastal populations from California to Oregon. The largest population is at Samoa Peninsula, California. Three other Humboldt County populations are nearby at Patricks Point State Park, Humboldt Lagoons State Park, and College Cove State Beach. The two known sites in Oregon are Sutton Creek Recreation Area, Siuslaw NF and Cape Blanco State Park. Only two populations are on federal land (Siuslaw NF and parts of the Samoa Peninsula). One population is outside the range of the Northwest Forest Plan, in San Luis Obispo County, California.

Specific Habitat: *Bryoria pseudocapillaris* grows on exposed trees (especially Sitka spruce and shore pine) and shrubs on coastal windswept dunes and rocky headlands at or near sea level within 3 km (1-2 mi) of the ocean in areas of frequent fog.

Threats: The main threats are activities that directly harm the populations, their habitat, or the potential habitat surrounding populations. Examples of potential threats include: burning (in some places); harvesting trees; constructing roads, trails or buildings; recreational activities; grazing; invasive exotic plants; changes in local hydrology; and air pollution.

Management Recommendations:
- Manage known sites to maintain local populations and their habitat.
- Develop practices to route human use away from known sites.
- Manage fire in the habitat areas, with emphasis on prevention.
- Restrict removal of trees, shrubs, or other vegetation from known sites except when removal will not harm habitat integrity.

Information Needs:
- Visit known sites to determine the extent of local populations and improve habitat descriptions.
- Determine if the species is closely associated with late-successional and old-growth forests.
- Determine if additional populations exist in areas identified as potential suitable habitat.

I. NATURAL HISTORY

A. Taxonomy and Nomenclature

B. pseudocapillaris Brodo & D. Hawksw. was described in 1977 (Brodo and Hawksworth 1977). No nomenclatural changes nor synonyms have followed. It was placed in the *Implexae* section of *Bryora*, which includes the following, mainly coastal species: *B. capillaris*, *B. friabili*s, *B. implexa*, *B. nadvornikiana*, *B. pikei*, *B. pseudofuscescens*, *B. salazinica* and *B. spiralifera*. The section is characterized by β-orcinol depsidones other than fumarprotocetraric acid, small pseudocyphellae and a characteristic cortical structure that tends to make the branches more friable than usual. Because of their unusual pseudocyphellae, Brodo and Hawksworth placed both *B. pseudocapillaris* and the rare California endemic, *B. spiralifera*, in this group, but with some hesitation. The distinctively long depressed pseudocyphellae and pale to reddish-brown color of both species are closer to the chemically similar genus, *Sulcaria,* and the two species may actually have an intermediate taxonomic standing between *Bryoria* sect. *implexae* and the genus *Sulcaria*. In addition, similarities in branching type, color, and habitat requirements between *B. pseudocapillaris* and *B. spiralifera* indicate they are very closely related.

B. Species Description

1. Morphology and Chemistry

B. pseudocapillaris is a dark, filamentous, epiphytic lichen (**Figure 1**). It is fruticose and subpendent, 5-7 cm long, and somewhat stiff. Thallus color varies from very pale brown to chestnut-colored, and has a matt (not shiny) surface. The branching pattern is mainly isotomic dichotomous (branches in y's of equal size) and acute to perpendicular angled short side branches are frequent. The main branches are mostly round in cross section, between 0.25-0.33 mm diameter, and are even, smooth, and neither flattened nor twisted. True lateral spinules, isidia, and soralia are absent. The long (1.2-3.0 mm), white pseudocyphellae are distinctively depressed and usually linear, although they can sometimes be slightly twisted around the filaments (branches). Sexual reproductive structures such as apothecia and pycnidia are unknown. The cortex is K+ yellow, C+ pink, KC+ pink, PD+ deep yellow; the medulla is K-, C-, KC-PD-. This lichen contains alectorialic and barbatolic acids, together with an unidentified substance (Brodo and Hawksworth 1977).

B. pseudocapillaris can be confused with two other chestnut-colored coastal tree hair lichens; *B. spiralifera* is most similar. It is known only from coastal Humboldt County, California, and from Bluegill Lake, Oregon Dunes National Recreation Area. It differs from *B. pseudocapillaris* by its K+ red, C-, and KC+ red reactions of the cortex, and the extremely long (up to 4 mm), spiraling pseudocyphellae. The unique deep, longitudinal sulcae (grooves or fissures) of *Sulcaria badia* readily distinguish it from *B. pseudocapillaris* (McCune and Geiser 1997).

Pale individuals of *B. pseudocapillaris* can be confused with other pale coastal tree hair lichens:

- *B. capillaris* is the most common pale brown to pale grayish *Bryoria* in the Coast Range. Although they both contain alectorialic and barbatolic acids and have the same reaction to chemical spot tests, *B. capillaris* lacks the frequent short side branches typical of *B. pseudocapillaris* and has short, inconspicuous (as opposed to long, white, conspicuous) pseudocyphellae.
- *B. capillaris* also tends to darken in exposed locations, but *B. pseudocapillaris* is always very pale (McCune *et al*. 1997). The two species also differ in habitat: *B. capillaris* is primarily a lichen of sheltered forests, but *B. pseudocapillaris* grows in exposed sites along the immediate coast (McCune *et al*. 1997).
- *B. trichodes* ssp. trichodes is easily distinguished from *B. pseudocapillaris* by its K-, C- and KC- spot tests. In addition, the medulla is usually P+ red (contains fumarprotocetraric acid), as opposed to P+ deep yellow (Brodo and Hawksworth 1977).

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- *B. subcana* has abundant, conspicuous, white soralia but soralia are never present in *B. pseudocapillaris.*
- *B. friabilis* has long, spiraling pseudocyphellae and a KC+ pinkish-orange reaction, but its K- and P- reactions, and uneven, wrinkled branches, readily distinguish it.
- *B. pseudofuscescens* has short, inconspicuous pseudocyphellae and is KC-.

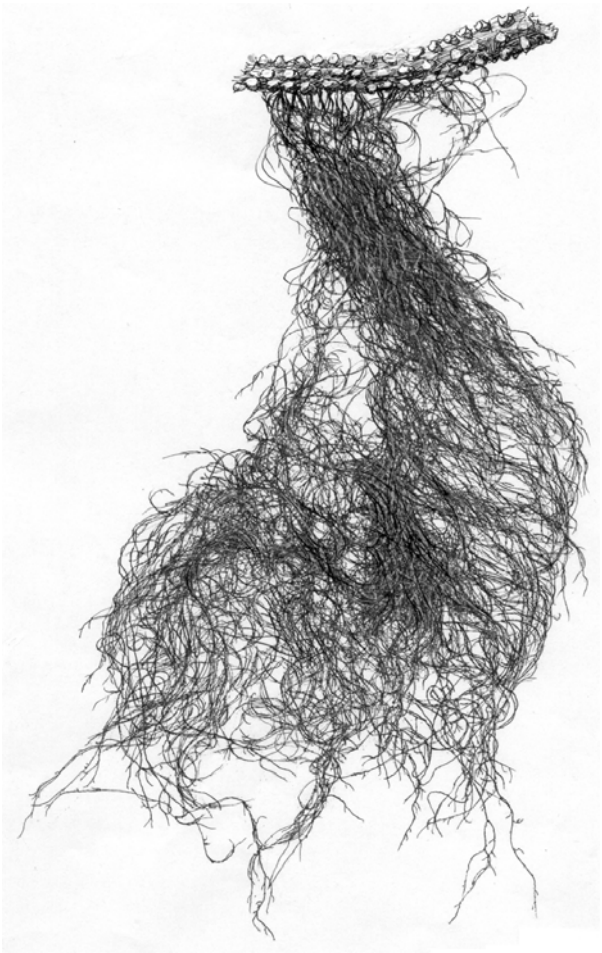

Figure 1. Line drawing of *Bryoria pseudocapillaris*.

2. Reproductive Biology

B. pseudocapillaris reproduces asexually by thallus fragmentation. Smaller asexual propagules containing both fungal and algal partners (e.g., soredia or isidioid spinules) are absent for this species, and sexual reproductive structures (fungal apothecia) have never been observed (Brodo and Hawksworth 1977).

Like other pendent lichens in the genera *Alectoria*, *Bryoria*, and *Usnea* that reproduce by thallus fragmentation (Esseen et al. 1981, Stevenson 1988, Dettki 1998), *B. pseudocapillaris* reproduces effectively over short distances (within a few hundred meters) but may be dispersal limited over long distances. Many lichens produce microscopic sexual and asexual propagules that are dispersed long distances by wind, animals, or birds (Bailey 1976). The thallus fragments of *B. pseudocapillaris* are less likely to be carried as far by wind or animal vectors. Because the habitat appears limited, even propagules which are transported across long distances are unlikely to encounter conditions suitable for establishment. In addition, because current populations are widely separated, and because *B. pseudocapillaris* apparently lacks the means for sexual reproduction, genetic diversity within populations might be low and exchange of genetic material between populations may be absent.

3. Ecological Roles

Little is known about the ecological roles of *B. pseudocapillaris*. Other *Bryoria* species provide forage and nesting material for a variety of animal species such as insects, birds, small mammals, and ungulates (McCune and Geiser 1997). The Samoa Peninsula is home to the largest population of *B. pseudocapillaris*. Because the lichen can be found abundantly draped over trees in many places, it is probable that some animals utilize it.

C. Range and Known Sites

The current world-wide distribution of *B. pseudocapillaris* consists of seven known populations, all but one in the range of the Northwest Forest Plan. *B. pseudocapillaris* is limited to a very few widely spaced populations, in exposed sites within 3 km (1-2 mi) of the Oregon and northern California coast. *B.*

pseudocapillaris was described by Brodo and Hawksworth in 1977 from two locations: at Cape Blanco (Curry County), Oregon, and from the Samoa Peninsula near Manila (Humboldt County). In almost a quarter century since, only five additional populations have been discovered, one at Sutton Creek, Siuslaw NF (Lane County, Oregon) (McCune et al. 1997), one near Baywood Park (San Luis Obispo County, California) — outside the range of the Northwest Forest Plan) (Riefner et al. 1995), and three more locations in the Arcata-Eureka vicinity of Humboldt County, California: Patricks Point State Park, Humboldt Lagoons State Park, and College Cove State Beach (Glavich, pers. comm.). There is little doubt that this lichen is both rare and also limited to the immediate coast as extensive surveys conducted by the Forest Service on seven National Forests, in over 1200 locations, have failed to locate any additional populations (USDA 1998).

D. Habitat Characteristics and Species Abundance

B. pseudocapillaris is a lichen of very narrow ecological amplitude, occurring in sites with moderated temperature and high humidity provided by frequent fog. It grows on exposed or moderately exposed coastal trees, shrubs, and (once) on rock, in old scrub forests of windswept dunes or rocky headlands, at or near sea level (< 50 m (165 ft) elevation). *B. pseudocapillaris* is found predominantly on shore pine (*Pinus contorta*) and Sitka spruce (*Picea sitchensis*). It shares the same habitat with a closely related California-Oregon endemic, *B. spiralifera.* On the Samoa Peninsula, it is frequently mixed with the draping, epiphytic lichen, *Ramalina menziesii* (Brodo and Hawksworth 1977). This species is rare throughout its narrow range.

The largest population of *B. pseudocapillaris* occurs on the Samoa Peninsula where it grows intermixed with the more abundant *B. spiralifera*. At Sutton Creek, just north of the Oregon Dunes, *B. pseudocapillaris* was found densely overgrowing a small, moribund conifer located in an exposed site between an old-growth Sitka spruce forest and open dunes (McCune et al. 1997).

Other Humboldt County populations were in second-growth. At Humboldt Lagoons State Park, it was found on Sitka spruce at the edge of Stone Lagoon. At Patrick's Point State Park and College Cove State Beach, it was found at the edge of Sitka spruce forests on marine terrace cliffs (Glavich, pers. comm.).

II. CURRENT SPECIES SITUATION

A. Why Species is Listed Under Survey and Manage Standard and Guideline

B. pseudocapillaris was considered at risk under the Northwest Forest Plan because of its rarity and limited distribution in the range of the northern spotted owl (USDA and USDI 1994a, 1994b). At the time, it was known from two populations world-wide, both in the range of the northern spotted owl (USDA and USDI 1994b). Viability concerns were based on its rarity and restriction to a specialized habitat: the fog zone within 3 km (1-2 mi) of the ocean. The viability ratings reflected a high level of concern for this species. The rare oceanic-influenced lichens as a group received the lowest viability ratings among all the lichens considered (USDA and USDI 1994a).

Because of the low viability ratings and high level of concern, this species was identified as a Survey and Manage Strategy 1 and 3 species (USDA and USDI 1994c), with the dual objectives of managing known sites and conducting extensive surveys to locate additional populations and identify other high-priority sites for species management.

B. Major Habitat and Viability Considerations

The major concerns are the small number of known populations, the limited amount of suitable habitat for this species on federal land, and the loss of populations from management or recreational activities that

damage populations or remaining habitat. Climate change or air pollution could also cause a decline in vigor of this species or contribute to extirpation of local populations.

Because of the small number of known sites world-wide, *B. pseudocapillaris* is one of the most threatened species on the survey and manage list of the Northwest Forest Plan. Discovering or establishing additional populations would lower concerns about its viability.

The persistence of this lichen is very uncertain because of the limited potential for federal management along the immediate coast and the very few known sites. The main population stronghold is the Samoa Peninsula, much of which is under private ownership. Timber harvest, expansion of the area open to recreational activities, or additional development could further restrict its habitat on the Samoa Peninsula, and elsewhere along the coast.

For species with inefficient means for long-distance dispersal, isolation of populations also leads to genetic isolation. Almost nothing is known about the genetics of lichen populations or the effects of gene pool isolation on local extinction rates of populations.

C. Threats to the Species

Threats to *B. pseudocapillaris* are those actions that disrupt stand conditions necessary for its survival. Such actions include treatments that reduce local populations by removing colonized bark or wood substrates; decreasing exposure to light; adversely affecting integrity of habitat areas; reducing or fragmenting potential habitat; or degrading air quality.

Recreational activities and developments may inadvertently alter the habitat of this species. Trampling by recreational vehicles and frequent foot traffic are serious threats, especially in shore pine woodlands and edge communities, as these degrade the habitat by disturbing fragile root systems of trees and shrubs and the fragile, protective mats of ground cryptogams, all of which stabilize the soil (Christy et al. 1998). Destabilization of the foredunes by recreationists or removal of European beachgrass (*Ammophila arenaria*) can destabilize tree island habitats of *B. pseudocapillaris* by increasing the amount of sand drift into them and burying trees on the perimeter (Christy et al. 1998). Buildings, roads, campgrounds and trails along the immediate coast have replaced many natural habitats to improve access, facilitate scenic views, or develop recreational uses.

Other threats to the integrity of habitat and potential habitat areas include logging, grazing, agriculture, and activities which alter local hydrology, or increase fire frequency (Christy et al. 1998). Concern about fire varies— many different plant communities and successional stages exist among the coastal dunes and headlands; fire is beneficial to some communities but damaging to others. Invasion or planting of exotics such as Scots broom (*Cytisus scoparium*), European beachgrass, tree lupine (*Lupinus arboreus*), birdsfoot-trefoil (*Lotus corniculatus*), and iceplant (*Mesembryanthemum* spp.) can have profound effects on nitrogen-poor dune soils by increasing nitrogen and soil moisture. These conditions foster invasion of other weeds, eventually disrupting native plant communities (Christy et al. 1998) and reducing plant and animal diversity (USDI 1997).

Although the air-pollution sensitivity of this species is unknown, other coastal members of this genus are sensitive to sulfur- and nitrogen-based acidifying pollutants (Wetmore 1983, Insarova et al. 1992, McCune and Geiser 1997). Because the primary habitat of this lichen is the coastal fog belt, and because fog significantly concentrates pollutants— especially acidic forms of SO_x and NO_x to which lichens are most sensitive— the potential vulnerability of *B. pseudocapillaris* to air-quality deterioration is a concern. Although air quality is generally good at known sites, rising pollution emissions from increased traffic (mainly NO_x) and new or expanded point sources (SO_x and NO_x) in the Arcata/Eureka vicinity, and elsewhere along the coast, might threaten this species in the future.

Climate change affecting coastal fog patterns could be expected to affect the vigor of this species, possibly resulting in an even more restricted distribution or contributing to local extirpation.

D. Distribution Relative to Land Allocations

There are three sites on federal land of *B. pseudocapillaris* in the range of the Northwest Forest Plan. One is the Sutton Creek Recreation Area, Siuslaw NF. The current land allocation designation is "administratively withdrawn", and management emphasis is recreation. The other federally-managed sites are the 618 acre Lanphere Dunes Unit on the Samoa Peninsula, part of the Humboldt Bay National Wildlife Refuge and a BLM parcel of the Samoa Peninsula (USDI 1997). Most of the Samoa Peninsula habitat is privately owned, but important habitat on the southern end of the peninsula is owned by the city of Eureka (Eureka Dunes Protected Area). A 100 acre parcel near the town of Manila (central peninsula) is owned by the Manila Community Services District and this, too, supports a large population of *B. pseudocapillaris*. The Cape Blanco site is an Oregon state park. Patricks Point, Humboldt Lagoons, and College Cove are state parks of California.

III. MANAGEMENT GOAL AND OBJECTIVES

A. Management Goal for the Taxon

The goal for managing *B. pseudocapillaris* is to assist in maintaining species viability.

B. Objectives

Manage populations at all known sites on federal lands by maintaining habitat and potential habitat immediately surrounding known populations.

IV. HABITAT MANAGEMENT

A. Lessons From History

Habitat destruction or alteration has made a significant contribution to the decline of lichens world-wide (Seaward 1977). Rare lichens that are limited to habitats optimal for human activities, such as *B. pseudocapillaris*, are especially vulnerable. At the northern end of the Samoa Peninsula, on county and state land near the mouth of the Little River, the native dune communities have been nearly eliminated by the invasion of European beachgrass and human activities, and only a tiny fragment of the dune forest remains. Lichens are also absent from the southern end of the Peninsula's dune forest, where the trees are young and there is more off-road vehicle evidence (Glavich, pers. comm.). At the Lanphere Dunes Unit, even hiking has been documented to damage fragile shore pine/bearberry (*Arctostaphylos uva-ursi*) communities (Brown 1990). In coastal Oregon, activities of the past 140 years: increased fire, agriculture and grazing, logging, changes in hydrology and recreation have affected plant succession in a major way (Christy et al. 1998). At Sand Lake dunes of Oregon, another hotspot of rare lichens, off-road vehicles have destroyed nearly all the shore pine woodlands in just thirty years (Wiedemann 1984, 1990 as cited by Christy et al. 1998).

Lichens have been known to be sensitive to air pollution more than a century. Populations of many species in eastern United States and Europe (Hawksworth and Rose 1976) have declined precipitously from exposure to sulfur dioxide and other air pollutants. In the United States, lichens are one of the components used to indicate stress to forests from air pollution (McCune et al. 1996), and dozens of studies in the United States have used lichens as air-quality indicators (see bibliography in USDA 1998). In the Pacific Northwest, sensitive species are already declining in some areas (Denison and Carpenter

1973, Taylor and Bell 1983) and lichens are identified as Air Quality Related Values in USDA Forest Service air resource management regional guidelines (Peterson *et al*. 1992).

B. Identifying Habitat Areas for Management

All known sites of *B. pseudocapillaris* on federal lands administered by the Forest Service and BLM in the range of the Northwest Forest Plan are identified as areas where these management recommendations should be implemented. Currently, the only known federally managed sites are the USFWS Lanphere Dunes Unit and a BLM parcel, both on the Samoa Peninsula, and the Sutton Creek Recreation Area of the Siuslaw NF. A habitat area for management is defined as suitable habitat occupied by or near a known population.

C. Managing in Habitat Areas

The objective of managing in habitat areas is to maintain the habitat conditions for *B. pseudocapillaris*. Specific recommendations are to:

- Determine the extent of the local population and habitat area with a site visit.
- Maintain suitable habitat around the current host trees and shrubs, so that the lichen may have adequate new substrate as current substrates decline.
- Develop practices to route human use away from the populations in habitat areas (e.g., divert roads, trails and off-road vehicles). Trampling shrubs or cryptogam mats, compacting roots, damaging trees or branches that serve as substrates, introducing non-native species by seed dispersal or planting, can all adversely affect habitat integrity.
- Avoid harvesting trees, shrubs, or other vegetation from the population and the habitat area unless these actions would do no harm to, or would improve, the habitat for *B. pseudocapillaris* (e.g., by preventing deeply shaded conditions or by removing invasive exotics).
- Prevent fire in the population but utilize or prevent fire in habitat areas, depending on the plant community, according to management guidelines suggested by Christy *et al*. (1998).
- Maintain integrity of the foredunes where they protect habitat areas.
- Restrict commercial collection of moss or fungi or other special forest products if these activities would adversely affect the integrity of habitat areas.

D. Other Management Issues and Considerations

- Consider opportunities for managing known sites during Forest Plan and Resource Management Plan revisions, such as Botanical Special Interest Areas, Areas of Critical Environmental Concern, or other administratively withdrawn designations, or by prescribing special standards and guidelines.
- Share information with state and private sectors to further activities directed at conserving *B. pseudocapillaris.*
- Continue to work with state and federal regulatory agencies to protect air quality on federally-managed lands from on- or off-site emissions, especially of nitrogen- and sulfur-containing pollutants.
- Provide information about conserving rare lichens at visitor centers or other locations along the coast to build public support of conservation efforts and to discourage collection of specimens.

V. RESEARCH, INVENTORY, AND MONITORING NEEDS

The objective of this section is to identify opportunities to acquire additional information that could contribute to more effective species management. The contents of this section have not been prioritized or reviewed as to how important the particular items are for species management. The inventory,

research, and monitoring identified below are not required. These recommendations should be addressed by a regional coordinating staff.

A. Data Gaps and Information Needs

- Revisit known sites to verify the status of the species, determine the extent of local populations, and better characterize habitat conditions.
- Determine if *B. pseudocapillaris* meets the criteria for being closely associated with late-successional and old-growth forests.
- Determine whether additional populations exist in areas identified as potentially suitable habitat, such as Gwynn Creek, Eel Creek on the Siuslaw NF; and inter-dune tree islands and scrub forests of the Oregon Dunes National Recreation Area; BLM parcels adjacent to Cape Lookout and other coastal BLM parcels.
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B. Research Questions

- What are the dispersal rates and mechanisms of *B. pseudocapillaris*?
- Which habitat and micro-climate characteristics are necessary for establishing *B. pseudocapillaris* thallus fragments and survival of established thalli?
- What is the genetic diversity of *B. pseudocapillaris* within local populations and across the region?
- What is the air pollution sensitivity of *B. pseudocapillaris*?
- What are the minimum and optimum patch sizes of colonized habitat necessary to provide for *B. pseudocapillaris?*
- Can transplants be used to create local populations of *B. pseudocapillaris* to increase its population base?
-

C. Monitoring Needs and Recommendations

- Monitor known sites for changes in microclimatic conditions, successional changes, and for inadvertent habitat damage from human activities or wildfire.
- Monitor dispersal and population trends of existing populations.
- Monitor air quality near key populations of *B. pseudocapillaris* on federally-managed lands (currently the Lanphere Dunes Unit (Humboldt Bay National Wildlife Refuge, USFWS) and Sutton Creek Recreation Area (Siuslaw NF)) and assess threats to this species from present or projected air-quality trends.

Bryoria spiralifera

SUMMARY

Species: *Bryoria spiralifera* Brodo & D. Hawksw.
Taxonomic Group: Lichens (Rare Oceanic-Influenced)
ROD Components: 1, 3

Other Management Status: Oregon Natural Heritage Program List 2 (taxa that are threatened with extirpation or presumed to be extirpated from the State of Oregon). Natural Heritage Networks Rank Global Rank G2? (rank of G2 is uncertain, but is defined as imperiled because of rarity or because other factors demonstrably make it very vulnerable to extinction (extirpation), typically with 6-20 occurrences). State Rank S1 (critically imperiled because of extreme rarity or because it is somehow especially vulnerable to extinction or extirpation, typically with 5 or fewer occurrences) (Oregon Natural Heritage Program 1998). BLM Assessment Status (USDI Bureau of Land Management 1998).

Range: *Bryoria spiralifera* is a rare lichen, endemic to coastal California and Oregon. In California, it is known from Humboldt County (Samoa Peninsula), Monterey County (Point Lobos), Sonoma County (Stewart's Point Road), and San Luis Obispo County (Baywood Park). In Oregon, it occurs in the Oregon Dunes National Recreation Area in the Bluebill Lake and Spinreel Campground vicinities.

Specific Habitat: *B. spiralifera* grows on exposed trees (especially Sitka spruce and shore pine) and shrubs on forested, coastal, windswept dunes and headlands at or near sea level within 3 km (1-2 mi) of the ocean. Frequent fog, and various ocean-influenced climatic, vegetative and edaphic factors appear to be important factors influencing the distribution of this species, which appears to have a narrow ecological amplitude.

Threats: The main threats are activities that directly harm the populations, their habitat, or the potential habitat surrounding populations. Examples of threats include: trampling from recreational activities, harvesting trees, constructing roads, trails or buildings, invasive exotic plants, burning (in some places), grazing; changes in local hydrology, and air pollution.

Management Recommendations:

- Manage known sites to maintain local populations and their habitat area.
- Develop practices to route human use away from known sites.
- Manage fire in the habitat areas, with emphasis on prevention.
- Restrict removal of trees, shrubs, or other vegetation from the known sites and habitat areas, except when removal will not harm habitat integrity.

Information Needs:

- Visit known sites to determine the extent of local populations and improve habitat descriptions.
- Determine if this species is closely associated with late-successional and old-growth forests.
- Determine if additional populations exist in areas identified as potential suitable habitat.

I. NATURAL HISTORY

A. Taxonomy and Nomenclature

B. spiralifera Brodo & D. Hawksw. was described in 1977 (Brodo and Hawksworth 1977) and has no synonyms. It was placed in the *B. implexae* section of *Bryoria*, which includes *B. capillaris*, *B. friabili*s, *B. implexa*, *B. nadvornikiana*, *B. pikei*, *B. pseudocapillaris*, *B. pseudofuscescens*, and *B. salazinica*. The section is characterized by the occurrence of β-orcinol depsidones other than fumarprotocetraric acid, small pseudocyphellae and a characteristic cortical structure that tends to make the branches more friable than usual. Because of their unusual pseudocyphellae, both *B. spiralifera* and *B. pseudocapillaris* were placed in this group with some hesitation. The distinctively long, depressed pseudocyphellae and pale brown to chestnut color of both species are closer to the chemically similar genus *Sulcaria*. The two species may actually have an intermediate taxonomic standing between the *Bryoria implexae* section and the genus *Sulcaria*. In addition, similarities in branching type, color, and ecology between *B. spiralifera* and *B. pseudocapillaris* indicate that they are particularly closely related.

B. Species Description

1. Morphology and Chemistry

B. spiralifera is a dark to pale reddish-brown, filamentous, epiphytic lichen (**Figure 2**). It has a short, pendent thallus, 6-7 cm long with conspicuous, long (up to 4 mm), white, linear, sometimes furrowed pseudocyphellae, most of which are twisted in long spirals around the branches. Other distinctive features are the numerous short, slender perpendicular branches, paler than the main branches. The main branches are 0.2-0.25 mm in diameter, uneven in cross section, and straight to twisted. The branching pattern is isotomic dichotomous at the base, with main branches becoming anisotomic dichotomous. True lateral spinules, isidia, and soralia are absent. Apothecia and pycnidia are unknown. The cortex is K+ red, C-, KC+ red, PD+ yellow; the medulla is K-, C-, KC-, and PD-. This lichen contains large amounts of norstictic acid, together with smaller quantities of connorstictic acid and atranorin (Brodo and Hawksworth 1977).

B. spiralifera can be confused with other chestnut-colored coastal treehair lichens. *B. pseudocapillaris* shares the same habitat. Although similar in appearance, the two species have a very different chemistry. *B. pseudocapillaris* contains only alectorialic and barbatolic acids, and the cortex is K+ yellow, C+ pink, and KC+ pink. It also has somewhat shorter (up to 3 mm) pseudocyphellae than does *B. spiralifera*, and they are mainly straight rather than spiraling. The unique deep, longitudinal sulcae (grooves or fissures) of *Sulcaria badia* easily distinguish it from *B. spiralifera*. *Nodobryoria oregana* is the most common reddish-colored *Bryoria* of the Coast Range and has short perpendicular side branches, but it lacks pseudocyphellae, usually has apothecia, and— because it contains no lichen substances— is K-, C-, KC-, and PD-.

Pale individuals of *B. spiralifera* can be confused with other pale coastal tree hair lichens:

- *B. capillaris* is the most common pale brown to pale grayish *Bryoria* in the Coast Range. Although they both contain alectorialic and barbatolic acids and have the same reaction to chemical spot tests, *B. capillaris* lacks the frequent short side branches typical of *B. spiralifera* and has short, inconspicuous (as opposed to long, white, conspicuous) pseudocyphellae. The two species also differ in habitat: *B. capillaris* is primarily a lichen of sheltered forests, but *B. spiralifera* grows in exposed sites along the immediate coast (McCune *et al*. 1997).

- *B. trichodes* ssp. *trichodes* is easily distinguished from *B. spiralifera* by its K-, C- and KC- spot tests. In addition, the medulla is usually P+ red (contains fumarprotocetraric acid), as opposed to P+ deep yellow (Brodo and Hawksworth 1977).
- *B. subcana* has abundant, conspicuous, white soralia but soralia are never present in *B. spiralifera*.
- *B. friabilis* has long, spiraling pseudocyphellae, but its K-, P-, and KC+ pinkish-orange reactions and uneven, wrinkled branches, readily distinguish it.
- *B. pseudofuscescens* has short, inconspicuous pseudocyphellae and is KC-.
- *B. pseudocapillaris* (see discussion above).
-

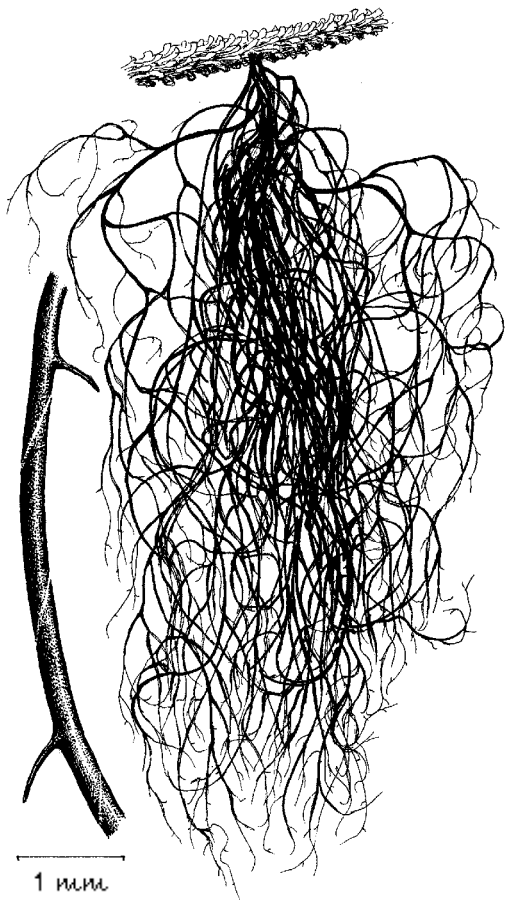

Figure 2. Drawing of *Bryoria spiralifera*.

2. Reproductive Biology

B. spiralifera reproduces asexually by thallus fragmentation. Smaller asexual propagules containing both fungal and algal partners (e.g., soredia or isidioid spinules) are absent for this species, and sexual reproductive structures (fungal apothecia) have never been observed (Brodo and Hawksworth 1977).

Like other pendent lichens in the genera *Alectoria*, *Bryoria* and *Usnea* that reproduce by thallus fragmentation (Esseen et al. 1981, Stevenson 1988, Dettki 1998), *B. spiralifera* reproduces effectively over short distances (within a few hundred meters) but may be dispersal limited over long distances. Many lichens produce microscopic sexual and asexual propagules that are dispersed long distances by wind, animals, or birds (Bailey 1976). The thallus fragments of *B. spiralifera* are less likely to be carried as far by wind or animal vectors. Because the habitat is rare, even propagules that are transported across long distances are unlikely to encounter conditions suitable for establishment. In addition, because current populations are widely separated, and because *B. spiralifera* apparently lacks the means for sexual reproduction, genetic diversity within populations may be low and exchange of genetic material between populations may be absent.

3. Ecological Roles

Little is known about the ecological roles of *B. spiralifera*. Other *Bryoria* species provide forage and nesting material for a variety of animal species such as insects, birds, small mammals, and ungulates (McCune and Geiser 1997). The Samoa Peninsula is home to the largest population of *B. spiralifera*. Because the lichen can be found abundantly draped over trees in many places, it is probable that some animals utilize it.

C. Range and Known Sites

The current world-wide distribution of *B. spiralifera* consists of five known sites. *B. spiralifera* is limited to a very few widely spaced populations, in exposed sites within 3 km (1-2 mi) of the California and Oregon coasts. Three known sites occur on federal land within the range of the Northwest Forest Plan: federally managed parts of the Samoa Peninsula (Humboldt County), and the Bluebill Lake vicinity

(*McCune 23696, 23700)* and Spinreel Campground vicinity in the Oregon Dunes National Recreation Area (Coos County).

B. spiralifera was described from a single location: the 15 km (9 mi) long, 1 km (0.6 mi) wide, Samoa Peninsula near Eureka and Arcata (Humboldt County, California) (Brodo and Hawksworth 1977). Current information suggests that this lichen is both rare and limited to the immediate coast as extensive surveys conducted by the Forest Service on seven National Forests, in over 1200 locations, located only the one site near Spinreel Campground (USDA 1998).

Riefner *et al*. (1995) reported three other California sites: Stewart's Point Road (Sonoma County), Baywood Park (San Luis Obispo County) and the Point Lobos vicinity (Monterey County). None are federally managed and the latter two locations are outside the range of the Northwest Forest Plan.

D. Habitat Characteristics and Species Abundance

B. spiralifera is a lichen of very narrow ecological amplitude. It grows on exposed or moderately exposed coastal trees, snags and shrubs, in forests or woodlands of windswept dunes and headlands. All known sites are at or near sea level (< 50 m (165 ft) elevation) and within 3 km (1-2 miles) of the ocean. *B. spiralifera* is found predominantly on shore pine (*Pinus contorta*) and Sitka spruce (*Picea sitchensis*) but is also found on grand fir (*Abies grandis*), evergreen huckleberry (*Vaccinium ovatum*), coyote bush (*Baccharis pilularis*) and, occasionally on red alder (*Alnus rubra*) and willow species (*Salix* spp.) (Glavich, pers. comm.). On the Samoa Peninsula, it is frequently mixed with the draping, epiphytic lichen, *Ramalina menziesii* (Brodo and Hawksworth 1977). It is known to be scattered but locally abundant near Bluebill Lake and on the Samoa Peninsula.

The following coastal plant communities, described by Christy *et al*. (1998), are preferred habitat for *B. spiralifera*: Sitka Spruce/Evergreen Huckleberry forest, Sitka Spruce-Shore Pine/Evergreen Huckleberry forest, Shore Pine/Hairy Manzanita (*Arctostaphylos columbiana*) woodland, and Shore Pine/Bearberry (*Arctostaphylos uva-ursi*) woodland. The largest population of *B. spiralifera* occurs on the Samoa Peninsula, where it achieves its highest density on the exposed branches in the canopy and on the edge of the moving dunes, especially on the oldest trees. Some of the old snags of shore pine and Sitka spruce, partially buried at the apex of a moving dune, support the largest, most well-established thalli (Glavich, pers. comm.). It also occurs in the canopy and edges of Sitka spruce-shore pine forests with thick to impenetrable understories of evergreen huckleberry, typical of dry stabilized dunes, tree islands, and deflation planes. It is also found in open shore pine woodlands with an understory of bearberry and mats of the reindeer lichen *Cladina*.

Although many of the habitat areas are not climax communities, *B. spiralifera* typically occupies older substrates within those communities. At the Lanphere Dunes Unit (Humboldt Bay National Wildlife Refuge, USFWS) on the Samoa Peninsula the oldest shore pine are approximately 150 years old (Glavich, pers. comm.). Mature shore pine in shore pine/bearberry woodlands at the Oregon Dunes National Recreation Area average between 80-130 years old. Sitka Spruce/Evergreen Huckleberry forests are mid-seral to climax communities and can contain Sitka spruce that are many centuries old (Christy *et al*. 1998).

II. CURRENT SPECIES SITUATION

A. Why Species is Listed Under Survey and Manage Standard and Guideline

B. spiralifera was considered at risk under the Northwest Forest Plan because it was thought to be a very rare lichen with a limited distribution (USDA and USDI 1994a, 1994b). At the time, it was known from one population world-wide (USDA and USDI 1994a, 1994b). The viability ratings reflected a high level

of concern for this species. The rare oceanic-influenced lichens as a group received the lowest viability ratings among all the lichens considered (USDA and USDI 1994a).

Because of the low viability ratings and high level of concern, this species was identified as a Survey and Manage Strategy 1 and 3 species (USDA and USDI 1994c), with the dual objectives of managing known sites, and conducting extensive surveys to locate additional populations and identify other high-priority sites for species management.

B. Major Habitat and Viability Considerations

The major concerns for *B. spiralifera* are the small number of known populations, limited amount of suitable habitat for this species on federal land, and loss of populations from management or recreational activities that damage the populations or the remaining habitat. Climate change or air pollution could also cause a decline in vigor of this species or contribute to extirpation of local populations.

Because of the small number of known sites world-wide, *B. spiralifera* is one of the most vulnerable species on the survey and manage list of the Northwest Forest Plan. Discovering or establishing additional populations would lower concerns about its viability.

The persistence of this lichen is very uncertain because of the limited potential for federal management along the immediate coast and the very few known sites. The main population stronghold is the Samoa Peninsula, much of which is under private ownership. Timber harvest, expansion of the area open to recreational activities, or additional development could further restrict its habitat on the Samoa Peninsula, and elsewhere along the coast.

For species with inefficient means for long-distance dispersal, isolation of populations also leads to genetic isolation. Almost nothing is known about the genetics of lichen populations or the effects of gene pool isolation on local extinction rates of populations.

C. Threats to the Species

Threats to *B. spiralifera* are those actions that disrupt stand conditions necessary for its survival. Such actions include treatments that reduce local populations by removing colonized bark or wood substrates; decreasing exposure to light; adversely affecting integrity of habitat areas; reducing or fragmenting potential habitat; or degrading air quality.

Recreational activities and developments may inadvertently alter the habitat of this species. Trampling by recreational vehicles and frequent foot traffic are serious threats, especially in shore pine woodlands and edge communities, as these degrade the habitat by disturbing fragile root systems of trees and shrubs and the fragile protective mats of ground cryptogams, all of which stabilize the soil (Christy *et al*. 1998). Destabilization of the foredunes by recreationists or removal of European beachgrass (*Ammophila arenaria*) can destabilize tree island habitats of *B. spiralifera* by increasing the amount of sand drift into them and burying trees on the perimeter (Christy et al. 1998). Buildings, roads, campgrounds and trails along the immediate coast have replaced many natural habitats to improve access, facilitate scenic views, or develop recreational uses.

Other threats to the integrity of habitat and potential habitat areas include logging, grazing, agriculture, and activities which alter local hydrology or increase fire frequency (Christy et al. 1998). Concern about fire varies—many different plant communities and successional stages exist among the coastal dunes and headlands; fire is beneficial to some communities but damaging to others. Invasion or planting of exotics such as Scots broom (*Cytisus scoparium*), European beachgrass, tree lupine (*Lupinus arboreus*), birdsfoot-trefoil (*Lotus corniculatus*), and iceplant (*Mesembryanthemum* spp.) can have profound effects on nitrogen-poor dune soils by increasing nitrogen and soil moisture. These conditions foster invasion of

other weeds, eventually disrupting native plant communities (Christy et al. 1998) and reducing plant and animal diversity (USDI 1997).

Although the air-pollution sensitivity of this species is unknown, other coastal members of this genus are sensitive to sulfur- and nitrogen-based acidifying pollutants (Wetmore 1983, Insarova et al. 1992, McCune and Geiser 1997). Because the primary habitat of this lichen is the coastal fog belt, and because fog significantly concentrates pollutants— especially acidic forms of SO_x and NO_x to which lichens are most sensitive— the potential vulnerability of *B. spiralifera* to air-quality deterioration is a reasonable concern. Although air quality is generally good at known sites, rising pollution emissions from increased traffic (mainly NO_x) and new or expanded point sources (SO_x and NO_x) in the Arcata/Eureka vicinity, and elsewhere along the coast, might threaten this species in the future.

Climate change affecting coastal fog patterns could be expected to affect the vigor of this species, possibly resulting in an even more restricted distribution or contributing to local extirpation.

D. Distribution Relative to Land Allocations

The population at Bluebill Lake is on a parcel of land administered by the Siuslaw NF, bordering the southern edge of the Oregon Dunes National Recreation Area. Although not Congressionally withdrawn, part of the area occupied by the population is managed for wildlife and plant viewing and part is an undeveloped area off-limits to motor vehicles. The population near Spinreel Campground may be inside the Oregon Dunes National Recreation area, and Congressionally withdrawn, or just outside. Most of the Samoa Peninsula is privately owned but the US Fish and Wildlife Service manages the Lanphere Dunes Unit (USDI 1997) and there are several parcels of land managed by the Bureau of Land Management.

III. MANAGEMENT GOAL AND OBJECTIVES

A. Management Goal for the Species

The goal for managing *B. spiralifera* is to assist in maintaining species viability.

B. Objectives

Manage populations at all known sites on federal land by maintaining habitat and potential habitat immediately surrounding known populations.

IV. HABITAT MANAGEMENT

A. Lessons From History

Habitat destruction or alteration has made a significant contribution to the decline of lichens world-wide (Seaward 1977). Rare lichens that are limited to habitats optimal for human activities, such as *B. spiralifera*, are especially vulnerable. At the northern Samoa Peninsula, on county and state land near the mouth of the Little River, the native dune communities have been nearly eliminated by the invasion of European beachgrass and human activities, and only a tiny fragment of the dune forest remains. Lichens are also absent from the southern end of the Peninsula's dune forest, where the trees are young and there is more off-road vehicle evidence (Glavich, pers. comm.). At the Lanphere Dunes Unit, even hiking has been documented to damage fragile shore pine/bearberry (*Arctostaphylos uva-ursi*) communities (Brown 1990). In coastal Oregon, activities of the past 140 years: increased fire, agriculture and grazing, logging, changes in hydrology and recreation have affected plant succession in a major way (Christy et al. 1998).

At Sand Lake dunes of Oregon, a hotspot for lichen diversity, off-road vehicles have destroyed nearly all the shore pine woodlands in just thirty years (Wiedemann 1984, 1990 as cited by Christy et al. 1998).

Lichens have been known to be sensitive to air pollution more than a century. Populations of many species in the eastern United States and Europe (Hawksworth and Rose 1976) have declined precipitously from exposure to sulfur dioxide and other air pollutants. In the United States, lichens are one of the components used to indicate stress to forests from air pollution (McCune et al. 1996) and dozens of studies in the United States have used lichens as air-quality indicators (see bibliography in USDA 1998). In the Pacific Northwest, sensitive species are already declining in some areas (Denison and Carpenter 1973, Taylor and Bell 1983) and lichens are identified as Air Quality Related Values in USDA Forest Service air resource management regional guidelines (Peterson et al.1992).

B. Identifying Habitat Areas for Management

All known sites of *B. spiralifera* on federal land administered by the Forest Service and BLM in the range of the Northwest Forest Plan are identified as habitat areas where these management recommendations should be implemented. A habitat area for management is defined as suitable habitat occupied by or near a known population.

C. Managing in Habitat Areas

The objective of managing in habitat areas is to maintain the habitat conditions for *B. spiralifera.* Specific recommendations are to:

- Determine the extent of the local population and habitat area with a site visit.
- Maintain suitable habitat around the current host trees and shrubs, so that the lichen may have adequate new substrate as current substrates decline.
- Develop practices to route human use away from the populations in habitat areas (e.g., divert roads, trails and off-road vehicles). Trampling shrubs or cryptogam mats, compacting roots, damaging trees or branches that serve as substrates, introducing non-native species by seed dispersal or planting, can all adversely affect habitat integrity.
- Avoid harvesting trees, shrubs, or other vegetation from the population and the habitat area unless these actions would do no harm to, or would improve, the habitat for *B. spiralifera* (e.g., by preventing deeply shaded conditions or by removing invasive exotics).
- Prevent fire in the population but utilize or prevent fire in habitat areas, depending on the plant community, according to management guidelines suggested by Christy, et al. (1998).
- Maintain integrity of the foredunes where they protect habitat areas.
- Restrict commercial collection of moss or fungi or other special forest products if these activities would adversely affect the integrity of habitat areas.

D. Other Management Issues and Considerations

- Consider opportunities for managing known sites during Forest Plan and Resource Management Plan revisions, such as Botanical Special Interest Areas, Areas of Critical Environmental Concern, or other administratively withdrawn designations, or by prescribing special standards and guidelines.
- Share information with state and private sectors to further activities directed at conserving *B. spiralifera.*
- Continue to work with state and federal regulatory agencies to protect air quality on federally-managed lands from on- or off-site emissions, especially of nitrogen- and sulfur-containing pollutants.
- Provide information about conserving rare lichens at visitor centers or other locations along the coast to build public support of conservation efforts and to discourage collection of specimens.

V. RESEARCH, INVENTORY, AND MONITORING NEEDS

The objective of this section is to identify opportunities to acquire additional information that could contribute to more effective species management. The content of this section has not been prioritized or reviewed as to how important the particular items are for species management. The inventory, research, and monitoring identified below are not required. These recommendations should be addressed by a regional coordinating staff.

A. Data Gaps and Information Needs

- Revisit known sites to verify the status of the species, determine the extent of local populations, and better characterize habitat conditions.
- Determine if *B. spiralifera* meets the criteria for being closely associated with late-successional and old-growth forests.
- Determine whether additional populations exist in areas identified as potentially suitable habitat, such as Gwynn Creek and Eel Creek on the Siuslaw NF; and inter-dune tree islands and scrub forests of the Oregon Dunes National Recreation Area; BLM parcels adjacent to Cape Lookout and other coastal BLM parcels.

B. Research Questions

- What are the dispersal rates and mechanisms of *B. spiralifera*?
- Which habitat and micro-climate characteristics are necessary for establishing *B. spiralifera* thallus fragments and survival of established thalli?
- What is the genetic diversity of *B. spiralifera* within local populations and across the region?
- What is the air pollution sensitivity of *B. spiralifera*?
- What are the minimum and optimum patch sizes of colonized habitat necessary to provide for *B. spiralifera?*
- Can transplants be used to create local populations of *B. spiralifera* to increase its population base?

C. Monitoring Needs and Recommendations

- Monitor known sites for changes in microclimatic conditions, successional changes, and for inadvertent habitat damage from human activities or wildfire.
- Monitor dispersal and population trends of existing populations.
- Monitor air quality near key populations of *B. spiralifera* on federal lands (currently the Lanphere Dunes (USFWS) and the Siuslaw NF) and assess threats to this species.

Bryoria subcana

SUMMARY

Species: *Bryoria subcana* (Nyl. ex Stizenb.) Brodo & D. Hawksw.
Taxonomic Group: Lichens (Rare Oceanic-Influenced)
ROD Components: 1, 3

Other Management Status: Oregon Natural Heritage Program List 3 (more information is needed before status can be determined, but may be threatened or endangered in Oregon or throughout their range). Natural Heritage Networks Rank Global Rank G4 (not rare and apparently secure, but with cause for long-term concern, usually with more than 100 occurrences). State Rank S1 (critically imperiled because of extreme rarity or because it is somehow especially vulnerable to extinction or extirpation in Oregon, typically with 5 or fewer occurrences) (Oregon Natural Heritage Program 1998). BLM Tracking Status (USDI Bureau of Land Management 1998).

Range: *Bryoria subcana* is known from five sites in the range of the Northwest Forest Plan. The Oregon sites are the Little Nestucca River and Cedar Lake vicinities, Hebo Ranger District, Siuslaw NF; Grass Mountain Area of Critical Environmental Concern on Salem District BLM; and Saddle Mountain State Park. The California site is Inverness Ridge in Marin County.

Specific Habitat: *B. subcana* grows on bark and wood of conifers in forests of coastal bays, streams, dune forests, and high precipitation ridges and summits within 50 km (30 mi) of the ocean.

Threats: The major threat to *B. subcana* is loss of populations from activities that directly affect the habitat or the population.

Management Recommendations:
- Manage known sites to maintain local populations and their habitat area.
- Develop practices to route human use away from known sites.
- Manage fire in the habitat areas, with emphasis on prevention.
- Restrict removal of trees, shrubs, or other vegetation from the known sites and habitat areas, except when removal will not harm habitat integrity.
- Consider opportunities for managing known sites during Forest Plan and Resource Management Plan revisions, such as administratively withdrawn designations, or by prescribing special standards and guidelines.

Information Needs:
- Visit known sites to determine the extent of local populations and improve habitat descriptions.
- Determine if *B. subcana* is closely associated with late-successional and old-growth forests.
- Determine whether additional populations exist in areas identified as potential suitable habitat.

I. NATURAL HISTORY

A. Taxonomy and Nomenclature

B. subcana (Nyl. *ex* Stizenb.) Brodo & D. Hawksw. was first described in 1892 by Stizenberger, who recognized it as a variety of *Alectoria prolixa* (*A. prolixa* var. *subcana* Nyl. ex Stiz.), a species complex originally described by Nylander. Gyelnik elevated the variety to species status in 1931 (*A. subcana* (Nyl. ex Stiz.) Gyeln.). In 1977, Brodo and Hawksworth subdivided the genus *Alectoria*, into *Alectoria, Bryoria, Pseudephebe*, *Sulcaria,* and *Oropogon*, and the current epithet was established. The type specimen of *B. subcana* was collected in Scotland in 1875 by J.M. Crombie (Herbarium Nylander 35835). *B. subcana* has also been known by at least 12 other names, none of which are currently used; Hawksworth (1972) details the long taxonomic history of this species.

Synonyms:

- *Alectoria haynaldii* Gyeln., Nyt Mag. Naturv. 70: 49 (1932)
- *Alectoria implexa* var. *subimplexa* Ndv., Klick Urcovn R Lisejnikd CSR 1: 122 (1956), *nom inval*. (Art. 36)
- *Alectoria jubata* var. *subcana* (Nyl. ex Stiz.) D.T. & Sarnth, Flecht. Tirol. 11 (1902)
- *Alectoria prolixa* var. *subcana* Nyl. ex Stiz, Annals Naturhist. Hofmus. Wien 7: 129 (1892)
- *Alectoria subcana* Nyl. ex Cromb., J. Bot., Lond. 14:360 (1876), *nom. inval*. (Art. 32)
- *Alectoria subcana* (Nyl. ex Stiz.) Gyeln., Magy. Bot. Lapok 30: 54 (1931)
- *Alectoria subcana* var. *obscurata* Mot., Fl. Polska, Porosty (2): 88 (1962), *nom. inval*. (Art. 37)
- *Alectoria subcana* var. s*ubosteola* (Gyeln.) Mot., Fl. Polska, Porosty (2): 88 (1962)
- *Bryopogon haynaldii* (Gyeln.) Zahlbr., Cat. Lich. Univ. 10: 557 (1940)
- *Bryopogon jubatus* var. *subcanus* (Nyl. ex Stiz.) Oksn., Viznachik Lishainikiv URSR: 276 (1937)
- *Bryopogon lanestris f. haynaldii* (Gyeln.) Gyeln., Feddes Repert. 38: 227 (1935)
- *Bryopogon subcana* (Nyl. ex Stiz.) Gyeln., Feddes Repert. 38: 226 (1935)
- *Bryopogon subosteolus Gyeln*., Acta Geobot. Hungar. 2: 164 (1937)

B. Species Description

1. Morphology and Chemistry

B. subcana is a short, pendant to almost tufted, fruticose lichen, up to 5 cm long (**Figure 3**). Its distinctive color (pale brown to greenish-white or whitish), nearly perpendicular branching angles, and typically abundant soralia, coupled with strong red color reaction of the cortex, medulla, and soralia to the spot chemical, *p*-phenylenediamine, differentiate it from very pale forms of *B. trichodes* ssp. *trichodes* that also grow near the coast (McCune and Geiser 1997).

The branching pattern is isotomic dichotomous, and the branches are round in cross-section, even in diameter, straight, often brittle, 0.15-0.3 mm in diameter. The basal parts are pale brownish- gray. The thallus surface is usually matte but occasionally shiny; apical parts are very pale brownish-gray to greenish-white or whitish, sometimes becoming variegated. True lateral spinules are absent. Pseudocyphellae are often present, sparse, inconspicuous, fusiform, and white. Soralia are usually abundant, tuberculate, as wide as or slightly broader than the branches on which they occur, occasionally becoming spinulose, to 0.8 mm in diameter. Apothecia and pycnidia have not been observed in North American material. Spot test reactions are K-, C-, KC, PD+ bright red (rapid). *B. subcana* contains large amounts of fumarprotocetraric acid (Brodo and Hawksworth 1977).

2. Reproductive Biology

Sexual reproductive structures are unknown for North American material. *B. subcana* reproduces asexually via soredia and thallus fragmentation.

Soredia are microscopic, usually spherical clusters of fungal mycelium and green algal cells that can be dispersed long distances by wind or animals. Birds can be important vectors, dispersing lichen propagules as a kind of litter along the migratory coastal highway (McCune et al. 1997). In contrast, thallus fragments are heavier and are more important for dispersal over short distances, usually within a few tree lengths.

3. Ecological Roles

Little is known about the ecological roles of *B. subcana*. Other *Bryoria* species provide nesting material and forage for small mammals (Maser et al. 1985 and 1986, Rosentreter and Eslick 1993), and critical winter forage for ungulates (Stevenson and Rochelle 1984). Lichen foraging is optimal in late-seral and old-growth forests, places where there has been sufficient time to develop a large biomass (Stevenson and Rochelle 1984, Neitlich 1996).

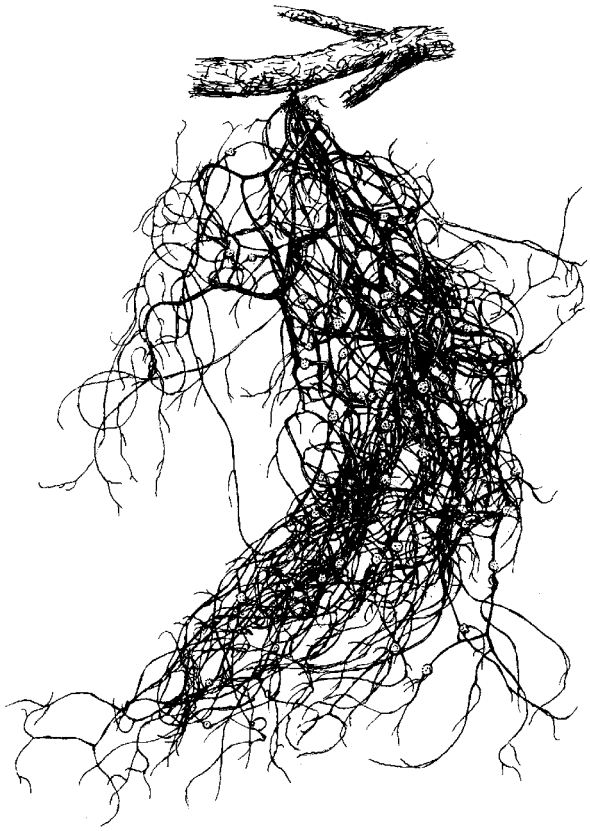

Figure 3. Line drawing of *Bryoria subcana*.

C. Range and Known Sites

B. subcana is known only from coastal western North America between south-central Alaska and central California (Brodo and Hawksworth 1977) and from Great Britain (Purvis et al. 1992). In the range of the Northwest Forest Plan, *B. subcana* is known from five sites, all within 50 km (30 mi) of the coast. There are two sites (USDA 1998) on Hebo Ranger District, Siuslaw NF. One is south of the Little Nestucca River about 5 km (3 mi) west of Dolph, and the other is north of Cedar Lake. The other Oregon sites are the summit of Saddle Mountain State Park (Clatsop County) (Pike 3818 in OSC Herbarium), and the summit of Grass Mountain (McCune et al. 1997), in Grass Mountain Area of Critical Environmental Concern (ACEC) on Salem District BLM (Benton County). In California, *B. subcana* is known from the Bolema Trail, Inverness Ridge area (Brodo and Hawksworth 1977) (Marin County); ownership of this site is unknown.

D. Habitat Characteristics and Species Abundance

B. subcana is found on bark and wood of conifers in Sitka spruce (*Picea sitchensis*), western hemlock (*Tsuga heterophylla*), wet Douglas-fir (*Pseudotsuga menziesii*), wet noble fir (*Abies procera*), and mixed hardwood-coniferous forests along coastal bays and streams, dune forests, coastal mountain ridges, and high precipitation summits. High humidity, either as coastal fog or high precipitation, appears to be an important habitat requirement. At the sites where stand age was noted, the host plant is old or the stand age is late-seral to old-growth. Requirements for light are not well understood. The lichen tolerates shade at two sites but canopy cover is low at other sites. In western North America, *B. subcana* has always been found within 50 km (30 mi) of the ocean.

At Inverness Ridge, *B. subcana* was found on the lower trunk of a Douglas-fir. At the Little Nestucca site, it was found mid-slope on a steep ridge, among red alders (*Alnus rubra*) and large, old western hemlocks. Exposure to light at this site was also low. At the Cedar Lake site, the lichen was found on Douglas-fir in an open, even-aged Sitka spruce/swordfern (*Polytrichum munitum*) forest of about 85 years. At the summits of Grass Mountain and Saddle Mountain it was found in wet noble fir forests, but the exposure is not known. (The tentative site at Eel Creek was an open canopy, mature western

hemlock/rhododendron (*Rhododendron macrophyllum*) dune forest with mats of the lichen *Stereocaulon* on the forest floor.)

Little information is available about species abundance. The species was noted as rare at two sites. No large populations have been identified.

II. CURRENT SPECIES SITUATION

A. Why Species Is Listed Under Survey and Manage Standard and Guideline

B. subcana was considered at risk under the Northwest Forest Plan because of its rarity and limited distribution in the range of the northern spotted owl (USDA and USDI 1994a, 1994b). At the time of the lichen viability panel, it was known from only one site (USDA and USDI 1994a, 1994b). Ratings by the viability panel reflected a high level of concern for this species. The rare oceanic-influenced lichens as a group received the lowest viability ratings among all of the lichens considered (USDA and USDI 1994a).

Because of the low viability ratings and high level of concern, this species was identified as a Survey and Manage Strategy 1 and 3 species with the dual objectives of managing known sites and conducting extensive surveys to find additional populations and identify other high-priority sites for species management (USDA and USDI 1994c).

B. Major Habitat and Viability Considerations

Frequent fog along the coast, and high precipitation summits of the Coast Range create a suitable environment for oceanic-influenced lichens such as *B. subcana*. The major concerns for this lichen are the small number of populations on federal land and loss of populations from management activities that directly harm the populations or impact habitat areas. Much of the coastal forest land in the Pacific Northwest is under non-federal ownership, generally managed on short harvest rotations. Given that lichens are slow to establish in rapidly growing stands and do not become abundant until later in successional development (USDA and USDI 1994a), most of these stands are harvested before lichens have a chance to establish significant populations. One explanation for the limited distribution of *B. subcana* is that it may not have time to establish significant populations in areas where there is frequent disturbance of host plant communities.

C. Threats to the Species

Threats to *B. subcana* are those actions that disrupt stand conditions necessary for its survival; such actions include treatments that reduce populations by removing colonized Sitka spruce, Douglas-fir, and noble fir, or other colonized bark or wood substrates; alter the light, moisture or temperature regime in habitat areas; or reduce air quality.

Recreational activities and developments may inadvertently alter the habitat of this species. Trampling by recreational vehicles and frequent foot traffic are serious threats, especially in shore pine woodlands and edge communities, as these degrade the habitat by disturbing fragile root systems of trees and shrubs, and the fragile, protective mats of ground cryptogams, all of which stabilize the soil (Christy et al. 1998). Destabilization of the foredunes by recreationists or removal of European beachgrass (*Ammophila arenaria*) can destabilize tree island habitats of *B. subcana* by increasing the amount of sand drift into them and burying trees on the perimeter (Christy et al. 1998). Buildings, roads, campgrounds, and trails along the immediate coast have replaced many natural habitats to improve access, facilitate scenic views, or develop recreational uses.

Although the air-pollution sensitivity of this species is unknown, other coastal members of this genus are sensitive to sulfur- and nitrogen-based acidifying pollutants (Wetmore 1983, Insarova et al. 1992, McCune and Geiser 1997). The primary habitat of this lichen is the coastal fog belt, and fog significantly concentrates pollutants— especially acidic forms of SO_x and NO_x to which lichens are most sensitive. Although air quality is generally good at known sites, rising pollution emissions from increased traffic (mainly NO_x) and new or expanded point sources (SO_x and NO_x) along the coast, might threaten this species in the future.

Climate change affecting coastal fog patterns could be expected to affect the vigor of this species, possibly resulting in an even more restricted distribution or contributing to local extirpation.

D. Distribution Relative to Land Allocations

The Little Nestucca River site is in the North Coast Adaptive Management Area, Hebo Ranger District, Siuslaw NF. The Cedar Lake site is in Unit 93, block III of the Hebo long-term restoration project. Grass Mountain is managed by the BLM as an Area of Critical Environmental Concern. Saddle Mountain State Park is owned and administered by the State of Oregon. The population in Marin County, California must be visited to determine ownership.

III. MANAGEMENT GOAL AND OBJECTIVES

A. Management Goal for the Species

The goal for managing *B. subcana* is to assist in maintaining species viability.

B. Objectives

Manage populations at all known sites on federal lands by maintaining habitat and potential habitat immediately surrounding known populations.

IV. HABITAT MANAGEMENT

A. Lessons from History

Habitat destruction or alteration has made a significant contribution to the decline of lichens world-wide (Seaward 1977). Rare lichens, such as *B. subcana*, that occur in habitats optimal for human activities, are especially vulnerable. In coastal Oregon, activities of the past 140 years: increased fire, agriculture and grazing, logging, changes in hydrology and recreation have affected plant succession in a major way (Christy et al. 1998). For example, at Sand Lake dunes of Oregon, a hotspot for lichen diversity, off-road vehicles have destroyed nearly all the fragile shore pine woodland habitat in just thirty years (Wiedemann 1984, 1990 as cited by Christy et al. 1998).

Lichens have been known to be sensitive to air pollution more than a century. Populations of many species in eastern United States and Europe (Hawksworth and Rose 1976) have declined precipitously from exposure to sulfur dioxide and other air pollutants. In the United States, lichens are one of the components used to indicate stress to forests from air pollution (McCune et al. 1996), and dozens of studies in the United States have used lichens as air-quality indicators (see bibliography in USDA 1998). In the Pacific Northwest, sensitive species are already declining in some areas (Denison and Carpenter 1973, Taylor and Bell 1983).

B. Identifying Habitat Areas for Management

All known sites of *B. subcana* on federal land administered by the Forest Service and BLM in the range of the Northwest Forest Plan are identified as areas where these management recommendations should be implemented. A habitat area for management is defined as suitable habitat occupied by or adjacent to a known population.

C. Managing in Habitat Areas

- Determine the extent of the local population and habitat area with a site visit.
- Maintain suitable habitat around the current host trees and shrubs, so that the lichen may have adequate new substrate as current substrates decline.
- Retain groups of standing trees to maintain suitable microclimate and to aid dispersal. Avoid harvesting or thinning trees, and removing shrubs or other vegetation in the population and habitat area, unless these actions would do no harm to, or would improve, the habitat for *B. subcana.*
- Prevent fire in the population but utilize or prevent fire in habitat areas, depending on the role of fire in the plant community. Consider recommendations by Christy et al. (1998) for fire management in coastal plant communities.
- Restrict commercial collection of moss, fungi or other special forest products if these activities would adversely affect the integrity of habitat areas.

D. Other Management Issues and Considerations

- Consider opportunities for managing known sites during Forest Plan and Resource Management Plan revisions, such as Botanical Special Interest Areas, Areas of Critical Environmental Concern, or other administratively withdrawn designations, or by prescribing special standards and guidelines.
- Continue to work with state and federal regulatory agencies to protect air quality on federally-managed lands from on- or off-site emissions, especially of nitrogen- and sulfur-containing pollutants.
- Provide information about conserving rare lichens at visitor centers or other locations along the coast to build public support of conservation efforts and to discourage collection of specimens.

V. RESEARCH, INVENTORY, AND MONITORING NEEDS

The objective of this section is to identify opportunities to acquire additional information which could contribute to more effective species management. The content of this section has not been prioritized or reviewed as to how important the particular items are for species management. The inventory, research, and monitoring identified below are not required. These recommendations should be addressed by a regional coordinating staff.

A. Data Gaps and Information Needs

- Determine the distribution of *B. subcana* in the range of the Northwest Forest Plan, focusing on potential suitable habitat— foggy Sitka spruce, western hemlock, true fir (Abies) and wet Douglas-fir forests of bays, rivers, steep slopes and ridges along the immediate coast, and high precipitation mountain summits within 50 km (30 mi) of the coast.
- Assign high priority to Strategy 3 surveys in areas where management treatments or projects are scheduled or proposed within 50 km (30 mi) of the ocean.
- Determine if *B. subcana* meets the criteria for being closely associated with late-successional and old-growth forests.

B. Research Questions

- What are the dispersal rates and mechanisms of *B. subcana*?
- Which habitat characteristics are necessary for establishing *B. subcana* propagules and survival of established thalli?
- Can stands be managed to mimic those characteristics?
- What are the minimum and optimum patch sizes of colonized habitat necessary to provide for *B. subcana*?
- How can conditions be optimized to encourage colonization of lichens from refugia into managed stands?
- What is the air pollution sensitivity of *B. subcana*?

C. Monitoring Needs and Recommendations

- Monitor known sites for changes in microclimatic conditions, successional changes, and for inadvertent habitat damage from human activities or wildfire.
- Monitor dispersal and population trends of existing populations.
- Establish air-quality monitoring sites near any key populations should air quality become an issue.

Bryoria subcana

Bryoria tortuosa

SUMMARY

Species: *Bryoria tortuosa* (G. Merr.) Brodo & Hawksw.
Taxonomic Group: Lichens (Rare Forage)
ROD Components: 1, 3

Other Management Status: None

Range: In the range of the Northwest Forest Plan, *Bryoria tortuosa* is distributed in the Puget Sound area, the eastern slopes of the Cascade Range, the Willamette Valley, and throughout northern California, including the coast. Of 78 records, 43 are on federal land. In Washington, there are 14 records from the Leavenworth Ranger District, Wenatchee NF. In Oregon, there are 20 records from the Barlow Ranger District, Mt. Hood NF; five records from the Deschutes NF, primarily on the Fort Rock Ranger District; and one record from Rough and Ready Creek on Medford District BLM. Single sites have been found on the Modoc, Klamath, and Shasta Trinity National Forests in California.

Specific Habitat: *B. tortuosa* grows on trees in well-lit, open stands, most frequently on oaks and pines, although it has been collected from a variety of trees and shrubs. In Oregon and Washington, it is most common east of the Cascade crest in the Douglas-fir Zone and Ponderosa Pine Zone.

Threats: Threats to *B. tortuosa* differ across its range. Habitat loss from human encroachment threaten coastal California, Willamette Valley and Puget Trough populations. Air pollution may threaten Puget Trough populations. In eastern Oregon and Washington, the principal threats are high-intensity fires and clear-cutting in habitat areas, especially when harvest intervals are less than 120 years. Thinning and low-intensity fires are not likely to threaten established populations of *B. tortuosa*, particularly if host trees are not targeted.

Management Recommendations:
- On the west side of the Cascade Range and in California, manage populations at known sites by maintaining the ecological conditions associated with *B. tortuosa*, including stand structure, substrate, and microclimate.
- On the east side of the Cascade Range, manage populations at the fifth field watershed level. When management activities are implemented near known sites, monitor populations to confirm that ecological conditions associated with *B. tortuosa* have been maintained.

Information Needs:
- Determine the status of known populations.
- Determine the ecological requirements and distribution of populations of *B. tortuosa* on federal land in the range of the Northwest Forest Plan.
- Determine the mechanisms and rates of reproduction, dispersal, and growth of *B. tortuosa*.
- Determine the air-pollution sensitivity of *B. tortuosa* and effects of air-quality trends on populations in the Puget Trough.

I. NATURAL HISTORY

A. Taxonomy and Nomenclature

B. tortuosa (Merr.) Brodo & D. Hawksw. was described by Merrill in 1909 as *Alectoria tortuosa*. In 1977, Brodo and Hawksworth subdivided the genus *Alectori*a, and the current epithet was assigned.

B. Species Description

1. Morphology and Chemistry

B. tortuosa (Brodo and Hawksworth 1977) is a pendent, filamentous lichen, 10-30 (- 40) cm long (Figure 5). The color is dull, dark, reddish-brown to dusky yellow-brown, occasionally becoming bright yellow in thalli having heavy concentrations of vulpinic acid. Branching is mainly anisotomic dichotomous; angles between the dichotomies are acute with frequent, slender, perpendicular side branches arising from the axes. Branches are uneven in diameter, strongly twisted and tortuous, foveolate and often flattened; 0.4-0.5 mm in diameter. Spinules and isidia are absent; soredia are exceedingly rare (known only from one specimen). The conspicuous, yellow pseudocyphellae are diagnostic. Pseudocyphellae are usually abundant, occasionally rare, bright yellow, linear or sometimes short fusiform, slightly raised, twisting around filaments in long yellow spirals. Apothecia are rare, lateral, with a raised, persistent, thalline exciple; the disc is strongly yellow pruinose. Spores are 7.5-8.7 x 4.7-5.0 µm, 8 per ascus, and hyaline ellipsoid. Pycnidia are unknown. All spot tests are negative (Brodo and Hawksworth 1977), but vulpinic acid may be extracted by acetone or by the alcohol used as a dilution for p-phenylenediamine, leaving a yellow color on test paper.

Specimens with low concentrations of vulpinic acid or sparse pseudocyphellae may be easily confused with the closely related species, *B. fremontii*. *B. fremontii* may have yellow soredia, that could be mistaken at first glance for the yellow pseudocyphellae of *B. tortuosa*. Thin-layer chromatography always reveals vulpinic acid in *B. tortuosa*, but it is only found associated with soralia and apothecia in *B. fremontii*. Brodo and Hawksworth (1977) or White and James (1985) can be consulted for thin layer chromatographic methods for lichen substances. Vulpinic acid concentration varies considerably, and pale and dark individuals often grow intermixed.

2. Reproductive Biology

B. tortuosa relies predominantly on thallus fragmentation, a form of vegetative propagation, for reproduction. Sexual reproduction in *B. tortuosa* is presumably rare because of the rarity of apothecia. Exceedingly rare individuals may also propagate asexually by soredia (Brodo and Hawksworth 1977).

Like other pendent lichens in the genera *Alectoria*, *Bryoria* and *Usnea* relying primarily on thallus fragmentation (Esseen *et al*. 1981, Stevenson 1988, Dettki 1998), *B. tortuosa* reproduces effectively over short distances (within a few hundred meters). It may be locally abundant, and *B. tortuosa* is the dominant epiphyte on trees in some locations. Dispersal over long distance is poorly understood but, in general, lichens that rely on thallus fragmentation produce many fewer propagules, of much greater mass, than species with smaller, or specialized propagules (e.g., soredia or isidia). If the probability of long distance transport is lower, the time required to disperse into young stands or establish many new individuals will be longer. This hypothesis is supported by the comparatively high proportion of species without specialized asexual reproductive structures that are old-growth associated (see discussion in Stevenson 1988). If the habitat is rare, or conditions unsuitable, even propagules that are transported across long distances are unlikely to establish new populations.

3. Ecological Roles

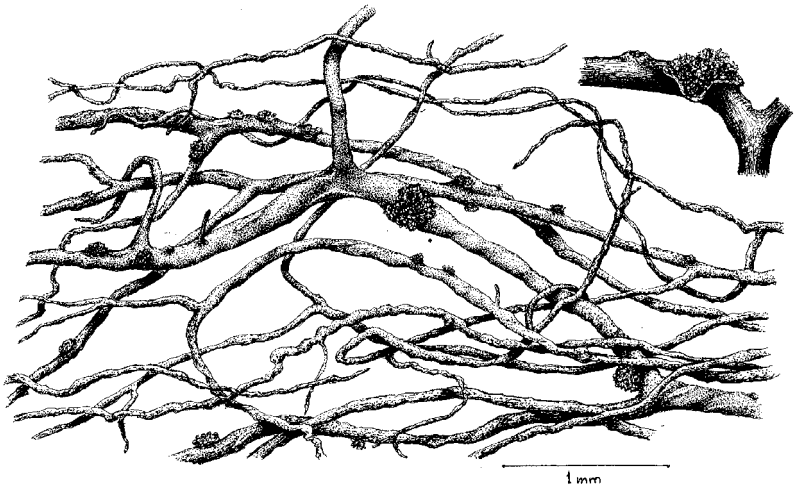

Figure 4. Drawing of *Bryoria tortuosa*.

B.tortuosa is a member of the rare forage lichen group in the Record of Decision for the Northwest Forest Plan (Table C-3) (USDA and USDI 1994c). *B. tortuosa* commonly grows intermixed with *B. fremontii*, a forage lichen that is the principal winter food source (Maser *et al*. 1985) and an important nesting material (Hayward and Rosentreter 1994) of the northern flying squirrel. Throughout the forests of the Pacific Northwest, species of *Bryoria*, *Alectoria*, and *Usnea* provide forage, nesting material, and habitat for many ungulates, other mammals, and many birds and invertebrates (McCune and Geiser 1997). Because *Bryoria* species often grow intermixed, and *B. fremontii* often occurs with *B. tortuosa*. *B. tortuosa* may also be used for nesting material and forage.

C. Range and Known Sites

B. tortuosa occurs in western North America (Brodo and Hawksworth 1977), and central Norway (Holien 1986). In North America, it grows along the Pacific Coast from southern British Columbia to central California and east to western Montana (Goward *et al*. 1994). In the range of the Northwest Forest Plan, the distribution is in the Puget Sound area, the eastern slopes of the Cascade Range, and throughout northern California, including the coast.

The Pacific Northwest has 78 records of *B. tortuosa*: 31 in Washington, 36 in Oregon, and 11 in California, many on federally managed lands. In the Puget Sound area of Washington, it is known from Deception Pass State Park and Goose Hill (Island County); Mt. Erie, Fidalgo Island, Phoebe Lake, and Cypress Island (Skagit County); the University of Washington Pack Forest, and along the White River (Pierce County). In eastern Washington, it is known from a site 24 km (15 mi) west of Ellensburg (Kittitas County); from 14 sites on the Leavenworth Ranger District, Wenatchee NF (Chelan County); and from 6 sites east of the Cascade Crest in the Columbia River Gorge (Klickitat County): on milepost 22.6, Road 142; on Balsh Road; Mud Spring Canyon; and Catherine Creek. In western Oregon, it is known from Eagle Point (Jackson County), and Medford District BLM Rough and Ready Creek Botanical Wayside (Josephine County), both in the low elevation Siskiyou Mountains; and from the sites near Veneta, Elmira, and Spencer Creek (Lane County) in the Willamette Valley. Eastern Oregon has about 20 known sites on the Barlow Ranger District of the Mt. Hood NF (Wasco County); and five sites on the Deschutes NF, mainly on the Fort Rock Ranger District, but also on the Bend, Sisters, and Crescent ranger districts (Deschutes County). Along the California coast, *B. tortuosa* is known from the Samoa Peninsula and several undescribed coastal sites in Humboldt and Mendocino Counties. Inland sites in northern California include the Modoc NF (Modoc County); Walker Creek Road, Klamath NF (Siskiyou County); Weaver Creek, Shasta Trinity NF (Trinity County); and two sites near Burney (Shasta County).

D. Habitat Characteristics and Species Abundance

B. tortuosa grows on trees in well-lit, open stands, most frequently on oaks (*Quercus* spp.) and pines (*Pinus* spp.), although it has been collected on a large variety of trees and shrubs (Brodo and Hawksworth 1977). It prefers the drier habitats of the Pacific Northwest and is found in forest zones with 40-100 cm

(15-40 in) average annual precipitation. In the range of the Northwest Forest Plan, *B. tortuosa* is found in the driest parts of the Western Hemlock Zone (*Tsuga heterophylla*) of the Puget Sound area and the Northern California coast; the Douglas-Fir (*Pseudotsuga menziesii*) Zone and Ponderosa Pine (*Pinus ponderosa*) Zone east of the Cascade crest in Washington and Oregon (currently only known as far south as the Crescent Ranger District, Deschutes NF); the Douglas-fir-sclerophyll Zone of the low-elevation eastern Siskiyou Mountains; and the Willamette Valley oak (*Quercus garryana*) woodlands (see Franklin and Dyrness 1988 for vegetation descriptions). It is absent from the Sitka Spruce (*Picea sitchensis*) and Western Hemlock zones of the Coast Range and western Cascades of Oregon and Washington, and also from the high elevation areas dominated by true fir (*Abies* spp.) and mountain hemlock (*Tsuga mertensiana*) in the Cascade Mountains. In northern California, the habitat of *B. tortuosa* is poorly known; existing records are geographically widespread, collected from ponderosa pine forests, mixed conifer-Douglas-fir forests and oak woodlands.

B. tortuosa appears well adapted to forests with frequent, natural, low-intensity fires. Most sites on the Barlow Ranger District, Mt. Hood NF, show evidence of past fire events, including scarring of trees that support large populations of *B. tortuosa*. It also appears well adapted to microsites with high light intensity, often on mature, open-grown trees or on trees along meadow edges or in young forests with scattered, remnant, mature or old-growth ponderosa pine. On the Leavenworth Ranger District of the Wenatchee NF, *B. tortuosa* has occasionally been found on the boles and lower branches in shady, dense, young stands of lodgepole pine (*Pinus contorta* var. *latifolia*) in areas of intentional fire suppression. The largest population, however, was found in an exposed site along the edge of a power line. A common characteristic of all known sites is the presence of at least some mature or old-growth trees on the site, usually more than 120 years old.

B. tortuosa is known to be locally abundant in the dry forest zones of eastern Oregon and Washington, especially the narrow Ponderosa Pine Zone on the eastern slope of the Washington Cascades. On Barlow Ranger District of the Mt. Hood NF, it is particularly common in the Ponderosa Pine-Oregon White Oak/Bitterbrush (*Pinus ponderosa*-*Quercus garryana*/*Purshia tridentata*) plant association. *B. tortuosa* is also widespread east of the Cascade crest in the Douglas-fir Zone, but these populations tend to be smaller and more scattered. Populations in the Douglas-fir Zone occur on the Barlow Ranger District and in central Washington on the Leavenworth Ranger District of the Wenatchee NF, where the Douglas-fir Zone directly borders the shrub steppe. *B. tortuosa* may be rarest on the northern California coast and in the Puget Sound area, which includes some low-elevation areas on the Mt. Baker-Snoqualmie NF. Throughout its range, the most common host trees are ponderosa pine, lodgepole pine, Oregon white oak and California black oak (*Quercus kelloggii*), Douglas-fir and western larch (*Larix occidentalis*). It has also been found on grand fir (*Abies grandis*), Pacific yew (*Taxus brevifolia*), Pacific madrone (*Arbutus menziesii*), and manzanita (*Arctostaphylos*). California coastal records came from old shore pine (*Pinus contorta* var. *contorta*) in stabilized sand dunes and the coastal Douglas-fir-Western Hemlock zone.

II. CURRENT SPECIES SITUATION

A. Why Species Is Listed Under Survey and Manage Standard and Guideline

B. tortuosa was considered at risk under the Northwest Forest Plan because of its apparent rarity and limited distribution in the range of the northern spotted owl (USDA and USDI 1994a, 1994b). Ratings by the lichen viability panel reflected a high level of concern for this species (USDA and USDI 1994a). At that time, only three locations were documented in the range of the northern spotted owl.

Because of the low viability ratings and high level of concern, this species was identified as a Survey and Manage Strategy 1 and 3 species (USDA and USDI 1994c), with the dual objectives of managing known sites and conducting extensive surveys to find additional populations and identify other high-priority sites for species management.

B. Major Habitat and Viability Considerations

The major concern for *B. tortuosa* is loss of populations from management activities that directly affect the habitat or the populations. Air pollution and continued habitat loss from human encroachment, especially in the Puget Sound area, could result in a decline in vigor of this species, resulting in an even more restricted distribution, or may result in local extirpation. *B. tortuosa* is rare along the coastal portion of its range in California, where continued habitat loss is also a consideration.

Recent surveys by Forest Service botanists on the Mt. Hood, Deschutes, and Wenatchee NFs and the Columbia River Gorge National Scenic Area have documented many more populations of *B. tortuosa* than were known during the FEMAT viability panel ratings. These newly discovered populations are confined to two vegetation zones: Douglas-fir and the Ponderosa Pine zones east of the Cascade crest in Oregon and Washington. *B. tortuosa* will probably continue to be found only rarely in western Oregon and Washington as systematic (every 3.4 mi), forest-wide epiphytic macrolichen surveys have yielded only one new site west of the Cascade crest (USDA 1998).

C. Threats to the Species

Threats to *B. tortuosa* are those actions that disrupt stand conditions necessary for its survival, including treatments that disturb populations by removing timber, altering the light, moisture, or temperature regime; or declining air quality.

Although the air-pollution sensitivity of this species is unknown, other members of this genus are sensitive to pollutants containing sulfur and nitrogen (Wetmore 1983, Insarova *et al*. 1992, McCune and Geiser 1997). The threat of air-pollution-influenced extirpation is greatest in the Puget Trough area, where the lichen is already considered rare, and pollution emissions from the Seattle-Tacoma metropolitan area are expected to increase with urban and industrial growth.

Along the coast of California, the greatest threat may be continued habitat loss from land development, timber harvest, grazing, and agriculture on private lands. Short rotation lengths do not allow sufficient time for re-establishment of large populations. Known sites typically contain at least some trees more than 120 years old. Recreational activities or developments on state and federal lands could inadvertently destroy habitat of this species.

East of the Cascade Crest in Oregon and Washington, the principal threats are clear-cutting in the Ponderosa Pine and Douglas-fir zones, especially if harvest intervals are less than 120 years. Thinning and low-intensity fires are not likely to threaten established populations of *B. tortuosa*, particularly if host trees are not destroyed.

Inland of the coast in northern California, where the species may be rare, the primary threat is the inadvertent destruction of unreported populations.

D. Distribution Relative to Land Allocations

At least 57 locations of this species are on federal land. Single locations were found on the Klamath, Shasta-Trinity, and Modoc NFs, but the records in Brodo and Hawksworth (1977) are not specific enough to determine land allocation status. The site at the Medford District BLM Rough and Ready Botanical Wayside is administratively withdrawn. The majority of known sites on the Mt. Hood and Wenatchee NFs are in project planning areas, although the land allocations for these sites need to be determined, as well for the six known sites in the Columbia River Gorge National Scenic Area, and 11 known sites on the Deschutes NF. Land ownership for the White River site in Pierce County needs to be determined.

III. MANAGEMENT GOAL AND OBJECTIVES

A. Management Goal for the Taxon

The goal for managing *B. tortuosa* is to assist in maintaining species viability.

B. Objectives

Manage populations at all known sites on federal lands by maintaining habitat and potential habitat immediately surrounding known populations.

IV. HABITAT MANAGEMENT

A. Lessons From History

Habitat destruction or alteration has made a significant contribution to the decline of lichens world-wide (Seaward 1977). The extirpation or decline of these species has been attributed to both cutting of forest, short rotations between timber harvesting, air-quality degradation and slow dispersal and establishment rates of lichen species (Alstrup and Søchting 1989, Broad 1989, Esseen et al. 1981). *B. tortuosa* may be especially vulnerable where it is rare and its limited habitat is subject to many different human-caused disturbances, such as the Puget Sound lowlands, Willamette Valley and near the Pacific Coast.

Conversion of old-growth forests into young managed stands normally leads to a significant reduction in epiphytic lichen biomass, which in turn can have negative consequences for animals that use canopy lichens as food, shelter, or nesting material (Esseen et al. 1996). For example, Pettersson *et al*. (1995) documented the loss of songbird populations resulting from intensive forestry; short rotations reduced the biomass of lichens that supported insect populations which were the songbirds primary food source.

Lichens have been known to be sensitive to air pollution for more than a century. In the eastern United States and Europe, sensitive lichens are absent from many locations as a result of sulfur dioxide and other forms of pollution (Brodo 1966, Hawksworth and Rose 1976, Showman and Long 1992, McCune *et al*. 1997). In the Pacific Northwest, sensitive species have already declined in some areas (Denison and Carpenter 1973, Taylor and Bell 1983) and lichens are identified as Air Quality Related Values in USDA Forest Service air resource management regional guidelines (Peterson *et al*. 1992).

B. Identifying Habitat Areas for Management

All known sites of *B. tortuosa* on federal land administered by the Forest Service and BLM in the range of the Northwest Forest Plan are identified as areas where these management recommendations should be implemented. A habitat area for management is defined as suitable habitat occupied by or near a known population.

C. Managing in Habitat Areas

The objective of managing habitat areas is to maintain the habitat conditions for *B. tortuosa.* Specific known habitat conditions for *B. tortuosa* include well-lit, open stands of Douglas-fir, ponderosa pine, lodgepole pine and oak. Determine the extent of the local population and habitat area with a site visit. Because concern about this species differs across its geographical range, specific management recommendations are based on location:

East of the Cascade Crest in Oregon and Washington

- Manage *B. tortuosa* within fifth-field watersheds to maintain representative populations.
- Because *B. tortuosa* is typically found in exposed situations and on host trees that show evidence of fire scarring, some treatments, such as thinning and low-intensity prescribed or natural fire are not likely to be detrimental to the long-term survival of populations in eastern Oregon and Washington.
- Although *B. tortuosa* is restricted in its ecological distribution, it may be locally common in certain areas. Determine the extent of the local population and habitat area with a site visit. If a population of *B. tortuosa* is growing in a project area, evaluate the importance of the population relative to other known sites, and its contribution to the persistence of the species. Consider the landscape and ecological context of the population; e.g., factors such as the location of the population relative to other known populations, its relative isolation, the ecological conditions of the site and how they compare to other known sites (typical or atypical), the areal extent of the population and abundance of the lichen in the local population, and availability of suitable habitat in the area. Each local population should be maintained intact, but affecting a small percentage of known individuals at a particular site may be acceptable if it does not damage the viability or integrity of the local population.
- Maintain occupied substrate, and provide for a distribution of appropriate substrate and associated microclimatic conditions and forest structure in areas of known populations.
- Special consideration should be given to maintain populations near the edge of the geographical range of *B. tortuosa*, and in watersheds where it is rare and of limited distribution.
- If stands at known sites are treated, the older cohort should be maintained as source of inoculum. Larger, older trees should be selected for retention, particularly those that are colonized by *B. tortuosa*.

West of the Cascade Crest in Oregon and Washington, and Northern California

- On the west side of the Cascade crest and in northern California, substrate and occupied habitat should be managed to enhance habitat to maintain populations of *B. tortuosa*.
- Determine the extent of the local population and habitat area with a site visit.
- Manage sites with known populations to include an area large enough to maintain ecological conditions associated with *B. tortuosa*, including undisturbed forest structure, substrate, and associated microclimate.
- Maintain suitable habitat around the current host trees and shrubs, so that the lichen may have adequate new substrate as current substrates decline.
- Avoid harvesting trees, shrubs, or other vegetation from the population and habitat area unless these actions would do no harm to, or would improve, the habitat for *B. tortuosa* (e.g., by preventing deeply shaded conditions or by removing invasive exotics).
- Prevent intense fire in the population, but use prescribed fire, where appropriate, to maintain the habitat.

D. Other Management Issues and Considerations

Although the species appears to be more common than originally thought on the east side of the Cascades, the response of *B. tortuosa* to management treatments is unknown. Treated sites should be monitored to establish the range of treatments compatible with long-term persistence of *B. tortuosa* populations in these vegetation zones. If negative effects are noted, management prescriptions should be re-evaluated.

V. RESEARCH, INVENTORY, AND MONITORING NEEDS

The objective of this section is to identify opportunities to acquire additional information which could contribute to more effective species management. The content of this section has not been prioritized or reviewed as to how important the particular items are for species management. The inventory, research, and monitoring identified below are not required. These recommendations should be addressed by a

regional coordinating staff.

A. Data Gaps and Information Needs

- Determine the distribution of east side populations relative to the land area covered by the Northwest Forest Plan.
- Determine the distribution of *B. tortuosa* in northern California and west of the Cascade crest.
- On the westside of the Cascades and in northern California, give high priority to Strategy 3 surveys in areas where management treatments or projects are scheduled or proposed. Conduct surveys to find populations of *B. tortuosa* in areas identified as potentially suitable habitat.
- Revisit larger populations on the east side of the Cascade crest to examine stand structure, disturbance history, and ecological conditions. Use this information to determine the habitat requirements and response of *B. tortuosa* to disturbance.
- Revisit known sites on the west side of the Cascade crest to determine the status of the species, the extent of the populations, and better characterize habitat conditions.

B. Research Questions

- How does *B. tortuosa* respond to forest clearing activities (thinning, harvesting, road building), particularly changes in light, temperature, and moisture regimes?
- What are the dispersal rates and patterns of *B. tortuosa*?
- What habitat characteristics are necessary for survival and establishment of *B. tortuosa* propagules?
- Can stands be managed to mimic those characteristics?
- What are the minimum and optimum patch sizes of colonized habitat necessary to provide for *B. tortuosa*?
- How sensitive is *B. tortuosa* to air-pollution?

C. Monitoring Needs and Recommendations

- Monitor populations of *B. tortuosa* and their response to different management treatments to determine which treatments are successful at maintaining populations and suitable habitat for *B. tortuosa*.
- Monitor air-quality trends of sites on federal land in the Puget Trough and Willamette Valley and the response of *B. tortuosa* to changes in air quality.

Buellia oidalea

SUMMARY

Species: *Buellia oidalea* (Nyl.) Tuck.
Taxonomic Group: Lichens (Rare Oceanic-Influenced)
ROD Components: 1, 3

Other Management Status: Oregon Natural Heritage Program List 3 (more information is needed before status can be determined, but may be threatened or endangered in Oregon or throughout their range). Natural Heritage Networks Rank Global Rank G4 (not rare and apparently secure, but with cause for long-term concern, usually with more than 100 occurrences). State Rank S1 (critically imperiled because of extreme rarity or because it is somehow especially vulnerable to extirpation in Oregon, typically with 5 or fewer occurrences) (Oregon Natural Heritage Program 1998). BLM Tracking Status (USDI Bureau of Land Management 1998).

Range: In the range of the Northwest Forest Plan, *Buellia oidalea* is known from six locations. Two are in Washington: Narbeck Creek and Squalicum Mountain. Two are in Oregon: Sixes River, and ocean-side of Carter Lake, Oregon Dunes National Recreation Area on the Siuslaw NF. Two are in California: Lanphere Dunes Unit (Humboldt Bay National Wildlife Refuge, USFWS) on the Samoa Peninsula, and Patricks Point State Park.

Specific Habitat: *B. oidalea* is found from sea level to 200 m (700 ft) along the Pacific Coast, usually within 3 km (2 mi) of the ocean. It is corticolous and lignicolous on a wide variety of coniferous and deciduous trees and shrubs. In the area of the Northwest Forest Plan, it has been collected from red alder, Monterey cypress, Sitka spruce, shore pine, Douglas-fir, willow, on redwood posts, and shrubs. In southern California, it has been reported on a variety of substrates.

Threats: The major threat to *B. oidalea* is loss of populations from activities that adversely affect the population, habitat or potential habitat, including future declines in air quality.

Management Recommendations:
- Manage known sites and their habitat areas.
- Develop practices to route human use away from habitat areas.
- Prevent fire in the population; manage fire in habitat areas.
- Restrict removal of trees, shrubs, or other vegetation from the habitat area.
- Consider opportunities for managing known sites during Forest Plan and Resource Management Plan revisions, such as administratively withdrawn designations, or by prescribing special standards and guidelines.

Information Needs:
- Visit known sites to determine the extent of local populations and improve habitat descriptions
- Determine if *B. oidalea* is closely associated with late-successional and old-growth forests.
- Determine if additional populations exist in areas identified as potential suitable habitat.

I. NATURAL HISTORY

A. Taxonomy and Nomenclature

B. oidalea (Nyl.) Tuck. was originally described in 1857 by Nylander as *Lecidea aliena* Nyl.

Synonyms:

Lecidea oidalea Tuck, Proc. Am. Acad. Arts and Sci. 4: 405. 1860.
Buellia aliena (Nyl.) Herre, Bryologist 20:84. 1917.
Rhizocarpon oidaleum (Nyl.) Fink, Mycologia 21:306. 1919.
Buellia oidalea (Tuck.) Tuck., Lich. Californ. p. 26. 1866.

B. Species Description

1. Morphology and Chemistry

B. oidalea is a thin yellowish to grayish-green crustose lichen growing on the trunks, branches and twigs of trees and stumps (**Figure 5**). Individual thalli have a black perimeter (the hypothallus) and small black apothecia lacking margins. The identity of *B. oidalea* must be verified from microscopic characters of the fruiting bodies (see below). *B. oidalea* is most likely to be confused with *B. oidaliella*, *B. penichra* and *B. muriformis*, and the distinctions between these four species are discussed in detail by Nordin (1999 and 2000). *B. penichra* is an inland species of the Siskiyous, Sierras, eastern Cascades, and Northern Rockies and *B. oidaliella* is known so far only from Baja California. The distribution of *B. muriformis* overlaps that of *B. oidalea* but spot test reactions are K+ y and PD+ y in *B. muriformis* (containing atranorin and placodiolic acid) and K- and PD- in *B. oidalea* (containing diploicin). In addition, *B. oidalea* has a yellowish thallus, larger spores, and thickened spore walls and septae compared to *B. muriformis*, which has a whitish gray thallus.

Technical description: Thallus yellowish-glaucescent, contiguous, from thin, cartilaginous and smoothish, soon rimulose, thickened and rugose-verrucose to pronouncedly warty, limited by a black hypothallus. Apothecia round, adnate, 0.8-2.0 mm across; the disk black, at first plane but soon strongly convex or tumid (inflated, swollen); the margin concolorous, thin, soon excluded by the tumid disk. Hypothecium brown-black, not extending as a tail into the thallus. Exciple continuous with the hypothecium, concolorous. Hymenium colorless, interspersed with oil drops, 140-230 µm thick; the paraphyses semi-distinct, lax, branched, septate, fusco-capitate, apical cell enlarged; the asci swollen clavate, 2-, 3-, 6- or 8- spored. Spores oblong-ellipsoid, brown, muriform, 6-10 septate transversely and 2-5 septate longitudinally, (28) 32-55 (78) x (12) 14-21 (24) µm (Imshaug 1951). Photobiont chlorococcoid (Dobson 1992). Chemical reactions: Thallus PD-, K-; hymenium I+ (deep blue).

2. Reproductive Biology

B. oidalea reproduces sexually by producing ascospores in apothecia. Vegetative reproduction is unknown (McCune et al. 1997). The microscopic size of the reproductive propagules should enable them to be carried long distances by wind, animals or birds. Birds in particular are thought to enhance arrival rates of rare oceanic species like *B. oidalea* by dispersing lichen propagules along coastal migratory routes of the Pacific Northwest (McCune et al. 1997).

3. Ecological Roles

Little is known about the ecological roles of *B. oidalea*. Various molluscs and insects (e.g., bristletails, barklice, katydids, grasshoppers, webspinners, butterflies, moths, lacewing larvae, mites, spiders, snails, slugs, and many beetles) live on or mimic lichens, or graze upon the algal rich layer and reproductive structures (Gerson and Seaward 1977)

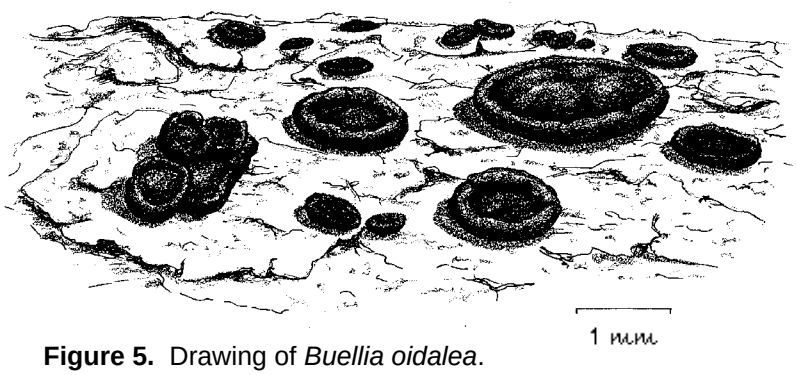

Figure 5. Drawing of *Buellia oidalea*.

C. Range and Known Sites

B. oidalea is endemic to the Pacific Coast of North America, ranging from Baja California, Mexico, north to Vancouver Island, British Columbia. Primarily known from California, it has been collected from scattered locations northwards. In his treatment of lichen-forming members of the genus *Buellia* in North America, Imshaug (1951) reported *B. oidalea* as endemic to Baja California and California south of San Francisco Bay. He examined more than 50 collections from Alameda, Los Angeles, Marin, Monterey, Orange, Sacramento, San Diego, San Francisco, San Luis Obispo, Santa Barbara, Santa Cruz, and Ventura Counties.

In the range of the Northwest Forest Plan, *B. oidalea* is known from six locations. Two are in Washington (Narbeck Creek, Snohomish County; and Squalicum Mountain, Whatcom County). Two locations are in Oregon: Sixes River (Curry County); and ocean-side of Carter Lake, Oregon Dunes National Recreation Area, Siuslaw NF (Douglas County). The last two sites were reported by McCune et al. (1997). There are two locations in California: Lanphere Dunes Unit Humboldt Bay National Wildlife Refuge, USFWS (Samoa Peninsula, Humboldt County); and Patricks Point State Park (Humboldt County). Only two sites are on federally-managed lands: Carter Lake in Oregon Dunes National Recreation Area and the Lanphere Dunes Unit. Two additional reports in Oregon: Coburg Hills Relict Forest Island Area of Critical Environmental Concern (ACEC) on Eugene District BLM (Linn County) and Medford District BLM Picnic Area at Howard Prairie Lake (Jackson County) are not coastal and identifications from these sites should be verified.

D. Habitat Characteristics and Species Abundance

B. oidalea is found from sea level to 200 m (700 ft) along the Pacific Coast, usually within 1 km (0.6 mile) of the ocean. It grows on the bark and wood of a wide variety of coniferous and deciduous trees and shrubs (Imshaug 1951). In southern California, it has been found on *Adenoctonia*, *Audibertia*, manzanita (*Arctostaphylos*), ceanothus (*Ceanothus*), mountain-mahogany (*Cercocarpus*), ocotillo (*Fouquieria*), *Iriglams*, toyon (*Heteromeles*), *Opuntia*, pine (*Pinus*), apple (*Pyrus*), oak (*Quercus*), sumac (*Rhus*), coast redwood (*Sequoia*), and California laurel (*Umbellularia*). In the range of the Northwest Forest Plan, it has been collected from red alder (*Alnus rubra*), Monterey cypress (*Cupressus macrocarpa*), Sitka spruce (*Picea sitchensis*), shore pine (*Pinus contorta*), Douglas-fir (*Pseudotsuga menziesii*), and willow (*Salix*), on redwood posts, and on shrubs. Its occurrence on young shore pine on the deflation plain coastward from Carter Lake (Douglas County) suggests that it is more common north of California than the few records would indicate (McCune et al. 1997). No information on species abundance is available. *B. oidalea* is confined to low elevation, coastal sites, especially south of the San Francisco Bay. Although the specific habitat preferences of *B. oidalea* have not yet been identified, this and other rare lichen species of coastal Oregon are not randomly distributed. Certain areas, topographic positions, and landforms have unusual concentrations of the rare species. Some lichens are most common

on the major headlands and capes, but others are found among dune vegetation. Two kinds of dune vegetation seem to hold the most species: old, open conifer stands with a broken ericaceous understory and wetlands with large old shrubs (McCune et al. 1997)

II. CURRENT SPECIES SITUATION

A. Why Species Is Listed Under Survey and Manage Standard and Guideline

B. oidalea was considered at risk under the Northwest Forest Plan because of its rarity and limited distribution in the range of the northern spotted owl (USDA and USDI 1994a, 1994b). At the time, it was only known from two populations world-wide, both in the range of the northern spotted owl (USDA and USDI 1994a, 1994b). The viability ratings reflected a high level of concern for this species. The rare oceanic-influenced lichens as a group received the lowest viability ratings among all the lichens considered (USDA and USDI 1994a).

Because of the low viability ratings and high level of concern, this species was identified as a Survey and Manage Strategy 1 and 3 species (USDA and USDI 1994c), with the dual objectives of managing known sites and conducting extensive surveys to locate additional populations and identify other high-priority sites for species management.

B. Major Habitat and Viability Considerations

Frequent fog along the coast, combined with moderate temperatures, create a suitable environment for ocean influenced lichens such as *B. oidalea*. The major concerns for this lichen are the limited amount of suitable habitat on federal land and loss of populations from management and recreational activities that adversely affect the remaining habitat or populations.

Climate change and air pollution are secondary threats. Degradation or change in these or any other habitat conditions mentioned above could affect the vigor of this species, possibly resulting in an even more restricted distribution or contributing to local extirpation.

C. Threats to the Species

Threats to *B. oidalea* are those actions that disrupt stand conditions necessary for its survival, such as treatments that reduce populations by removing colonies; adversely affecting integrity of habitat areas; reducing or fragmenting potential habitat; altering the light, moisture, or temperature regimes; or degrading air quality.

Other threats to the integrity of habitat and potential habitat areas include logging, grazing, agriculture, and activities which alter local hydrology, or increase fire frequency (Christy et al. 1998). Concern about fire varies— many different plant communities and successional stages exist among the coastal dunes and headlands; fire is beneficial to some communities but damaging to others. Invasion or planting of exotics such as Scots broom (*Cytisus scoparium*), European beachgrass (*Ammophila arenaria*), tree lupine (*Lupinus arboreus*), birdsfoot-trefoil (*Lotus corniculatus*), and iceplant (*Mesembryanthemum* spp.) can have profound effects on nitrogen-poor dune soils by increasing nitrogen and soil moisture. These conditions foster invasion of other weeds, eventually disrupting native plant communities (Christy et al. 1998) and reducing plant and animal diversity (USDI 1997).

Although air quality is generally good at known sites, rising pollution emissions from increased traffic (mainly NO_x) and new or expanded point sources (SO_x and NO_x) in the Arcata/Eureka vicinity, and elsewhere along the coast, might threaten this species in the future. The primary habitat of this lichen is

the coastal fog belt, and fog significantly concentrates pollutants— especially acidic forms of SO_x and NO_x to which lichens are most sensitive. The air pollution sensitivity of *B. oidalea* is not known

D. Distribution Relative to Land Allocations

Climate change affecting coastal fog patterns could be expected to affect the vigor of this species, possibly resulting in an even more restricted distribution or contributing to local extirpation.

Only two sites are known on federal lands. Carter Lake is part of the Oregon Dunes National Recreation Area, which is administratively withdrawn. Lanphere Dunes Unit is part of Humboldt Bay National Wildlife Refuge (USFWS). The Sixes River collection was made near a public landing in the Cape Blanco vicinity and may be state-owned. Patricks Point is a state park. The remaining sites are on private lands or of unknown ownership at this time.

III. MANAGEMENT GOAL AND OBJECTIVES

A. Management Goal for the Species

The goal for managing *B. oidalea* is to assist in maintaining species viability.

B. Objectives

Manage populations at all known sites on federal lands by maintaining habitat and potential habitat immediately surrounding known populations.

IV. HABITAT MANAGEMENT

A. Lessons From History

Habitat destruction or alteration has made a significant contribution to the decline of lichens world-wide (Seaward 1977). Rare lichens that occur in habitats optimal for human activities, such as the immediate coast, are especially vulnerable. In coastal Oregon, activities of the past 140 years including increased logging, recreation, agriculture and grazing, fire, and changes in hydrology have significantly altered plant succession (Christy et al. 1998). For example, at Sand Lake dunes of Oregon, an area of high lichen diversity, off-road vehicles have destroyed nearly all the fragile shore pine woodland habitat in just thirty years (Wiedemann 1984, 1990 as cited by Christy et al. 1998).

Lichens have been known to be sensitive to air pollution more than a century. Populations of many species in Europe (Hawksworth and Rose 1976) and eastern United States have declined precipitously from exposure to sulfur dioxide and other air pollutants. In the United States, lichens are one of the components used to indicate stress to forests from air pollution (McCune et al. 1996), and dozens of studies in the United States have used lichens as air-quality indicators (see bibliography in USDA 1998). In the Pacific Northwest, sensitive species are already declining in some areas (Denison and Carpenter 1973, Taylor and Bell 1983) and lichens are identified as Air Quality Related Values in USDA Forest Service regional guidelines (Peterson et al. 1992).

B. Identifying Habitat Areas for Management

All known sites of *B. oidalea* on federal land administered by the Forest Service and BLM in the range of the Northwest Forest Plan are identified as areas where these management recommendations should be

implemented. A habitat area for management is defined as suitable habitat occupied by or near a known population

C. Managing in Habitat Areas

The objective of managing in habitat areas is to maintain the habitat conditions for *B. oidalea.* Specific recommendations are to:

- Determine the extent of the local population and habitat area with a site visit.
- Maintain suitable habitat around the current host trees and shrubs, so that the lichen may have adequate new substrate as current substrates decline.
- Develop practices to route human use away from the populations in habitat areas (e.g., divert roads, trails and off-road vehicles). Trampling shrubs or cryptogam mats, compacting roots, damaging trees or branches that serve as substrates, introducing non-native species by seed dispersal or planting, can all adversely affect habitat integrity.
- Avoid harvesting trees, shrubs, or other vegetation from the population and the habitat area unless these actions would do no harm to, or would improve, the habitat for *B. oidalea* (e.g., by preventing deeply shaded conditions or by removing invasive exotics).
- Prevent fire in the population, but utilize or prevent fire in habitat areas, depending on the role of fire in the plant community. Consider recommendations by Christy et al. (1998) for fire management in coastal plant communities.

D. Other Management Issues and Considerations

- Information from reported sites suggests that *B. oidalea* may not meet the criteria for being closely associated with late-successional and old-growth forests. This issue should be addressed by a regional coordinating staff.
- Consider opportunities for managing known sites during Forest Plan and Resource Management Plan revisions, such as Botanical Special Interest Areas, Areas of Critical Environmental Concern, or other administratively withdrawn designations, or by prescribing special standards and guidelines.
- Share information with State and private sectors to further activities directed at conserving *B. oidalea.*
- Continue to work with state and federal regulatory agencies to protect air quality on federally-managed lands from on- or off-site emissions, especially of nitrogen- and sulfur-containing pollutants.
- Provide information about conserving rare lichens at visitor centers or other locations along the coast to build public support of conservation efforts and to discourage collection of specimens.

V. RESEARCH, INVENTORY, AND MONITORING NEEDS

The objective of this section is to identify opportunities to acquire additional information which could contribute to more effective species management. The content of this section has not been prioritized or reviewed as to how important the particular items are for species management. The inventory, research, and monitoring identified below are not required. These recommendations should be addressed by a regional coordinating staff.

A. Data Gaps and Information Needs

- Determine if *B. oidalea* meets the criteria for being closely associated with late-successional and old-growth forests.
- Visit known sites to determine the extent of local populations, and improve habitat descriptions.

- Determine whether additional populations exist in areas identified as potentially suitable habitat. Places where other rare coastal lichens have been found include: Siuslaw NF's Sutton Creek, Gwynn Creek, and the Oregon Dunes National Recreation Area; BLM parcels adjacent to Cape Lookout and other coastal BLM parcels.

B. Research Questions

- What are the dispersal rates and mechanisms of *B. oidalea*?
- Which habitat and micro-climate characteristics are necessary for establishing *B. oidalea* thallus fragments and survival of established thalli?
- What is the genetic diversity of *B. oidalea* within local populations and across the region?
- What is the air pollution sensitivity of *B. oidalea*? Can historic collections in now urbanized areas of southern California be relocated?
- What are the minimum and optimum patch sizes of colonized habitat necessary to provide for *B. oidalea* ?

C. Monitoring Needs and Recommendations

- Monitor known sites for changes in microclimatic conditions, successional changes, and for inadvertent habitat damage from human activities or wildfire.
- Monitor dispersal and population trends.

Buellia oidalea

Dendriscocaulon intracatulum

(Also called *Sticta* sp. #1)

SUMMARY

Species: *Dendriscocaulon intracatulum.* This name was used in the Record of Decision and may be misapplied to this lichen. The material from the Pacific Northwest is currently undergoing taxonomic revision.
Taxonomic Group: Lichen (Rare Nitrogen-fixing)
ROD Components: 1, 3

Other Management Status: None

Range: *Dendriscocaulon intracatulum* is a Pacific Northwest endemic ranging from southeastern Alaska through British Columbia; it reaches the apparent southern limit of its range in California. It is rare throughout its range, known only from 16 sites in the range of the Northwest Forest Plan. Eleven are in Washington, one on the Mt. Baker-Snoqualmie NF, eight on the Gifford Pinchot NF, and two in the Columbia River National Scenic Area. One Oregon site is on the Mt. Hood NF, and the other is on the Roseburg BLM District. The three California sites are on Horse Mountain, and near Arcata, and in Mendocino County on land of unknown ownership.

Specific Habitat: In the range of the Northwest Forest Plan, *D. intracatulum* appears to occupy two types of stand conditions: open-grown conifer and deciduous stands, and moist forests in the upper Western Hemlock and lower Pacific Silver Fir Zones in the western Cascades, between 10-660 m elevation (30-2170 ft). The open-grown sites are: in a stand of subalpine fir on a old lava flow; in California in lodgepole pine and bishop pine, a bigleaf maple woodland, and oak balds. Most of the Washington sites are in Douglas-fir, western hemlock, and Pacific silver fir forests.

Threats: The major threat to *D. intracatulum* is the impact to local populations from activities that affect the lichen or its habitat, including removing colonized substrates and altering microclimate by removing associated vegetation.

Management Recommendations:
- Maintain trees with colonies of *D. intracatulum*
- Maintain existing environmental conditions for local populations and adjacent suitable habitat.

Information Needs:
- Resolve the taxonomic status of this entity.
- Characterize the ecological requirements of the lichen.

I. NATURAL HISTORY

A. Taxonomy and Nomenclature

Current names:

- *Dendriscocaulon intricatulum* (Nyl.) Henss. (James and Henssen 1976)
- *Sticta oroborealis* Goward & Tønsberg, sp. *nov*. (Tønsberg & Goward 2001)
- *Sticta wrightii* (Tønsberg & Goward 2001)
- *Lobaria amplissima* (Tønsberg & Goward 2001)
- *Dendriscocaulon* sp. (Tønsberg & Goward 2001)

Synonyms:

- *Leptogidium intricatulum* Nyl., Syn. Lich. 1:135, 1858.
- *Polychidium intricatulum* (Nyl.) Henss., Symb. Bot. Upsal. 18:106, 1963.

The taxonomic identity of this entity is currently in flux. Evidence shows that at least some dendriscocauloid collections from northern California, British Columbia and southeastern Alaska are the free-living cyanobacterial photomorphs of *S. wrightii*, *L. amplissima*, and *S. oroborealis* (Tønsberg & Goward 2001). These finds and much earlier observations by James and Henssen (1976) have raised the question as to whether all dendriscocauloid materials are actually cyanobacterial photomorphs which, if true, could eventually invalidate the genus *Dendriscocaulon*. Another problem is that the name *D. intricatulum* is based on material from the Atlantic coast of North America. Because none of the eastern cyanolichens known to form dendriscocauloid cyanotypes occur in the Pacific Northwest, it is possible that the name *D. intracatulum* has been erroneously applied to material in the Pacific Northwest (Tønsberg & Goward 2001). Finally, there may be at least two distinct taxa in the Northwest Forest Plan area, as evidenced by the very different habitats this species occupies in the dry and wet parts of its range in Oregon, Washington and coastal California (Goward, Stone & Tønsberg, pers. comm.). Genetic comparisons are in progress (Tønsberg & Goward 2001) but for the time being, for lack of a better name, all dendriscocauloid lichens from the Pacific Northwest are herein referred to as *D. intracatulum*.

B. Species Description

1. Morphology

Because of the taxonomic uncertainty, a full technical description of *D. intracatulum* is not available. The blue-green photobionts of *D. intracatulum* are small, fragile, fruticose-coralloid, more or less hairy structures, rarely ridged in texture (**Figure 6**). The production of apothecia and pycnidia are unknown (James and Henssen 1976). *Leptogium teretiusculum*, a small gelatinous lichen, closely resembles *D. intracatulum*, but *D. intracatulum* is stratified and has fine tomentum visible with a high power hand lens, and *L. teretiusculum* is non-stratified and lacks tomentum (McCune, pers. comm.). *Polychidium contortum* is also similar to *D. intracatulum*, but *P. contortum* is smaller, and its jigsaw-shaped cells are obvious under the light microscope (McCune and Geiser 1997).

2. Reproductive Biology

D. intracatulum is not known to produce sexual or asexual propagules (spores or isidia). This lichen may reproduce asexually through fragmentation, given the brittle nature of the thallus. The rarity and patchy distribution of *D. intracatulum* suggests that it could be dispersal limited. The concept of dispersal includes the actual physical migration of propagules into new habitat, and the successful establishment and development of those propagules.

3. Ecological Roles

Little is known about the ecological roles of *D. intracatulum*. Evidence suggests that this lichen may be

an independent cyanobacterial outgrowth of a foliose green algal lichen in the genera *Sticta* and *Lobaria* (Tønsberg and Goward 2001). *D. intracatulum* is a nitrogen-fixing lichen, and contributes an unknown amount of usable nitrogen to the ecosystem. Although little is known about the pollution sensitivity of *D. intracatulum*, nitrogen-fixing lichens in general are highly sensitive to air pollutants, particularly sulfur dioxide (Wetmore 1983).

Figure 6. Drawing of *Dendriscocaulon intracatulum.*

C. Range and Known Sites

D. intracatulum is a North American endemic that ranges from southeastern Alaska (Geiser et al. 1998) through British Columbia (Goward *et al*. 1994, referenced as *Sticta* sp. #1) and reaches the apparent southern limit of its range in California (Tønsberg and Goward 2001). It is rare throughout its range, and known from only 16 sites in the range of the Northwest Forest Plan. Eleven of the sites are in Washington, one on the Mt. Baker-Snoqualmie NF (Whatcom County), eight on the Gifford Pinchot NF (Skamania County), and two in the Columbia River National Scenic Area (Skamania County). One Oregon site is on the Mt. Hood National Forest (Clackamas County), and the other is on the Roseburg BLM District (Douglas County). The three California sites are on Horse Mountain near the Six Rivers NF boundary and near Arcata (Humboldt County), and in Mendocino County on land of unknown ownership.

D. Habitat Characteristics and Species Abundance

At known sites in the range of the Northwest Forest Plan, *D. intracatulum* occurs between 10- 660 m (30-2170 ft) elevation in moist habitats. In the western Cascades it is known from riparian forests (two sites), upland old-growth in the Western Hemlock and Pacific Silver Fir Zones, mature Douglas-fir (*Pseudotsuga menziesii*)/western hemlock (*Tsuga heterophylla*) forests, and a stand of subalpine fir (*Abies lasiocarpa*) on an old lava flow. In northern California it is known from three sites in the coastal fog zone. It also occurs on the boles of oaks (*Quercus*) in oak balds at sites that appear to receive high levels of humidity from coastal influences. *D. intracatulum* is rare throughout its range, and only one or a few individuals are known from each site.

At the Gifford Pinchot NF closed-canopy sites, the lichen is found in the transition between the Western Hemlock and Pacific Silver Fir Zones. The Big Creek Falls site is an old-growth riparian stand of western hemlock and Pacific silver fir (*Abies amabilis*) with Pacific yew (*Taxus brevifolia*) in the understory. *D. intracatulum* was growing on small dead twigs on the lower portion of a western hemlock overhanging a 30-m (100-ft) cliff above the splash pool of a large waterfall. The Curly Creek Road site is a mature stand of Douglas-fir and western hemlock with old-growth components. A thorough survey over the course of several field visits revealed only about 10 individuals on about four different trees, again on small dead twigs at about eye level on western hemlock and Pacific silver fir. Other closed canopy sites are similar to the two described above, and vegetation types suggest that precipitation and humidity are high at all these sites.

On the Mt. Baker-Snoqualmie NF, *D. intracatulum* is found on subalpine fir on the Sulphur Creek Lava Flow, on a south-facing slope in a cold pocket. The mid-elevation (550-660 m and 1640-2170 ft) lava flow supports scattered live, dead, and dying subalpine fir infested with balsam woolly aphid. The stand has a dense shrub component of vine maple (*Acer circinatum*) and huckleberry (*Vaccinium* spp). The lava flow is unusual in that it supports relatively low-elevation subalpine fir (*Abies lasiocarpa*) stands with an epiphytic lichen flora that appears to be more similar to that of Douglas-fir stands than subalpine fir in its typical, higher elevation sites (Rhoades 1981). Although precipitation is high on the lava flow, soil development is poor and the site is very well-drained.

At the Horse Mountain (Humboldt County, California) site, *D. intracatulum* grows on open-grown bigleaf maple (*Acer macrophyllum*) in an oak woodland. This site is in the coastal fog zone with high humidity from the frequent fog (Sharnoff, pers. comm.). Many other cyanolichens were also present at this site. The other California site either in or next to the Van Damme State Park (Mendocino County) is part of the pygmy forest ecosystem. This unusual habitat occurs on old sea terraces that are poorly drained and have poor soil, so the cypress, lodgepole pine (*Pinus contorta*) and bishop pine (*Pinus muricata*) that grow there have a very stunted growth form (Sharnoff, pers. comm.). This ecosystem experiences high humidity because of the influence of coastal fog and the frequently saturated soil.

There are several recently discovered sites in the Columbia River Gorge, in Douglas County on Roseburg BLM District and in northern California near Arcata, where *D. intracatulum* was found growing on the mossy boles of open-grown oaks. The Columbia River Gorge and Arcata sites are areas that apparently receive high levels of humidity from coastal influences.

In British Columbia, *D. intracatulum* is known from a few moist, old, coniferous forests from sea level to 1000 m (0-3280 ft) elevation, where it is found on lower canopy conifer branches, and rarely on rocks (Goward, pers. comm.). In Southeast Alaska, it occurs at low elevation coastal mainland sites, on willows (*Salix*), alder (*Alnus*) and Sitka spruce (*Picea sitchensis*) (Geiser et al. 1998).

II. CURRENT SPECIES SITUATION

A. Why Species is Listed Under Survey and Manage Standard and Guideline

D. intracatulum was considered at risk under the Northwest Forest Plan because of its rarity and limited distribution in the range of the northern spotted owl (USDA and USDI 1994a,b). This lichen is endemic to the Pacific Northwest and reaches its apparent southern limit in northern California. Based on current information, this lichen is closely associated with old-growth forests. At the time of the FEMAT viability analysis, this lichen was known from only one site in the range of the northern spotted owl (USDA and USDI 1994a,b).

B. Major Habitat and Viability Considerations

A major habitat consideration for *D. intracatulum* is loss of local populations resulting from management activities that affect their habitat. These management activities include removing colonized trees and altering microclimate by tree removal. Apparent dispersal limitations could be a factor influencing persistence, particularly if suitable habitat is not available for the lichen to colonize, as current habitat conditions change through natural processes or management treatments.

C. Threats to the Species

Threats to *D. intracatulum* are from actions that disrupt stand conditions necessary for its survival. These include:

- Treatments that eliminate local populations by removing colonized trees.
- Altering the light, moisture, or temperature regime that would change the microclimatic conditions of an occupied site.
- Deteriorating air quality, particularly through an increase in sulfur dioxide.
- Collecting colonized twigs for firewood, particularly on Horse Mountain.

D. Distribution Relative to Land Allocations

The Sulphur Creek Lava Flow site on the Mt. Baker-Snoqualmie NF, is in a Botanical Special Interest Area in a Late-Successional Reserve (Hansen-Murray, pers. comm.). On the Mt. St. Helens National Volcanic Monument, Gifford Pinchot NF, the Big Falls Creek population is in a Riparian Reserve, while other sites nearby are in Matrix. The Curly Creek Road site is in Matrix and in an approved road project area; several colonized trees were removed for the road, and one colonized tree is now immediately adjacent to the new road. The Horse Mountain site is on land of unknown ownership, and the Mendocino County site is either in Van Damme State Park or on private land immediately adjacent to the park. The distribution of other known sites of *D. intracatulum* will be determined. It is suggested that each administrative unit evaluate the land allocations for known sites on lands in its jurisdiction and share this information at the regional level.

III. MANAGEMENT GOAL AND OBJECTIVE

A. Management Goal for the Taxon

The goal for managing *D. intracatulum* is to assist in maintaining species viability.

B. Objectives

Manage known sites on federal lands by maintaining habitat, forest structure, occupied and potential suitable substrate, and micro-climate conditions associated with *D. intracatulum.*

IV. HABITAT MANAGEMENT

A. Lessons from History

D. intracatulum is a rare Pacific Northwest endemic that is poorly understood. Because of taxonomic uncertainty, little is known about the lichen historically. *D. intracatulum* fixes nitrogen and many nitrogen-fixing species are particularly sensitive to sulfur dioxide (Wetmore 1983). In the Pacific Northwest, lichens are currently being used as indicators of air quality on public lands (Rhoades 1988; Ryan and Rhoades 1992; Stolte et al. 1993). In some parts of the Pacific Northwest, some nitrogen-fixing lichen species are beginning to decline and show morphological changes from air quality degradation (Denison and Carpenter 1973; Geiser, pers. comm.).

B. Identifying Habitat Areas for Management

All known sites of *D. intracatulum* on federal lands in the range of the Northwest Forest Plan are identified as habitat areas where these management recommendations should be implemented. A habitat area for management is defined as suitable habitat occupied by or adjacent to a known local population.

C. Managing in Habitat Areas

The objective of managing in habitat areas is to maintain suitable habitat for *D. intracatulum*. Because of its rarity, scattered distribution, and presumed dispersal limitations, all local populations should be maintained to provide for the lichen across its range.

- Determine the extent of the local population and habitat area with a site visit.
- Leave trees with *D. intracatulum* standing.
- Leave adequate standing trees and understory vegetation adjacent to colonized trees to maintain the microclimatic conditions, and to provide substrate for colonization. With the limited information available at this time, it is difficult to adequately identify *D. intracatulum* habitat requirements.

D. Other Management Issues and Considerations

The Curly Creek Road site on the Gifford Pinchot NF is at very high risk due to habitat removal. A major arterial road was built through the stand, removing one known colonized tree and leaving another colonized tree immediately adjacent to the road. Future pollution impacts from the new road are unknown. The Sulphur Creek Lava Flow site on the Mt. Baker-Snoqualmie NF is at moderate risk from habitat changes because the subalpine fir are declining from the balsam woolly aphid infestation (Rhoades 1981).

V. RESEARCH, INVENTORY, AND MONITORING NEEDS

The objective of this section is to identify opportunities to acquire additional information which could contribute to more effective species management. The content of this section has not been prioritized or reviewed as to how important the particular items are for species management. The inventory, research, and monitoring identified below are not required. These recommendations should be addressed by a regional coordinating staff.

A. Data Gaps and Information Needs

- The taxonomic status of this group needs to be resolved.
- The characteristics at the two different types of habitats needs to be better understood.
- Determine the ecological requirements of the lichen.
- Determine the mechanisms and rates of reproduction, dispersal, and growth.

B. Research Questions

- What is the taxonomy of *D. intracatulum*? Is it a valid lichen?
- Which environmental factors favor the development of the two different morphologies of *D. intracatulum*?
- How does this lichen disperse, and at what rate and distance?
- Which habitat characteristics are necessary for survival of propagules?

C. Monitoring Needs and Recommendations

- Monitor the Curly Creek road site to evaluate the response of the lichen to changes in microclimatic conditions, vegetation changes, and air quality.
- Monitor the Sulphur Creek Lava Flow site to determine the population trends of *D. intracatulum* after colonized trees die.
- Establish air quality biomonitoring sites near selected local populations, using protocols established by the Forest Service in Region 6.

Dermatocarpon luridum

SUMMARY

Species: *Dermatocarpon luridum* (With.) Laundon
Taxonomic Group: Lichens (Aquatic)
ROD Components: 1, 3

Other Management Status: None

Range: *Dermatocarpon luridum* is known from only 19 sites in the range of the Northwest Forest Plan, seven in Washington, nine in Oregon and three in California. It occurs in Washington on the Gifford Pinchot, Okanogan, Olympic, and Wenatchee NFs; Olympic National Park and in the San Juan Islands; in Oregon, on the Umpqua NF and Silver Falls and Mayer State; and in California, in the Klamath NF and Humboldt County on land of unknown ownership. The species is broadly distributed globally, but uncommon to rare in the Pacific Northwest.

Specific Habitat: This aquatic lichen grows on rocks, small boulders, and bedrock, submerged or seasonally emergent, adjacent to or in clear mountain streams between 105-1980 m elevation (1000-6500 ft), where it can be locally abundant. It is present on seepy terraces, and in streams and rivers with red alder, Douglas-fir, western hemlock and riparian vegetation ranging from young stands to old-growth, and in streams in alpine meadows.

Threats: The major threats to *D. luridum* are loss of populations resulting from activities that harm the population or affect its habitat. Altering stream conditions including water quality, chemistry, temperature, light regime, level, opacity, or sediment load, changing microclimatic conditions by altering the riparian canopy creates potential threats. Building and decommissioning roads (including culvert placement and removal), restoration activities, and fish enhancement projects using instream structures are threats. Activities upstream could impact sites downstream.

Management Recommendations:

- Because there may be dispersal limitations between streams, maintain *D. luridum* in each stream where it occurs.
- Maintain water quality parameters necessary for survival of *D. luridum.*
- Maintain riparian canopy conditions necessary for survival of *D. luridum.*
- Evaluate effects of treatment of riparian vegetation in populated stream reaches and the potential for reducing bank stability and increasing sediment input.

Information Needs:

- Determine if this species meets the criteria for being closely associated with old-growth.
- Determine stream conditions and range of riparian canopy conditions necessary for survival of *D. luridum.*

I. NATURAL HISTORY

A. Taxonomy and Nomenclature

D. luridum (With.) Laundon was described by Laundon in 1984.

Synonyms:

Dermatocarpon aquaticum (Weis) Zahlbr.
Dermatocarpon fluviatile (Weber) Th. Fr.
Dermatocarpon weberi (Ach.) Mann.

B. Species Description

1. Morphology and Chemistry

D. luridum is a freshwater aquatic, foliose, multi-lobed umbilicate lichen with a flabby texture, especially when wet (**Figure 7**). Upper surface is a drab brown when dry, turning bright green when wet; lower surface dark brown with occasional paler patches, mostly smooth but occasionally weakly wrinkled or papillate (Goward et al. 1994). The upper surface is commonly speckled with tiny black dots, which are perithecial openings (Purvis et al. 1992).

Technical Description: Thallus foliose or cushion-forming squamulose, more or less umbilicate, the squamules or individuals generally > 3 mm broad but mostly < 2 cm broad, often closely packed or shingled; upper surface usually not pruinose, light to dark brown, green when wet; lower surface smooth or with roundish bulges from the perithecia, or weakly wrinkled; perithecia common; spot tests negative (McCune and Geiser 1997).

2. Reproductive Biology

D. luridum reproduces sexually by producing fungal spores in perithecia. It may reproduce vegetatively by fragmentation of thallus lobes, which could drift to new sites and reattach to rocks. Aquatic invertebrates that graze on this lichen and ingest spores could also be dispersal vectors, as could downstream movement of colonized rocks.

3. Ecological Roles

D. luridum is an aquatic species, growing either submerged or seasonally emergent, immediately adjacent to higher order freshwater streams. It appears to be more tolerant to periods of desiccation than other aquatic lichens, perhaps because of the high humidity it receives during summer nights at high elevations. It is a good indicator of water quality and constancy of stream flow and may be particularly sensitive to siltation; it also provides habitat for aquatic invertebrates (USDA and USDI 1994a). Declines in aquatic lichen populations could adversely affect these invertebrates, which in turn provide food and nutrients to fish and other components of aquatic and terrestrial ecosystems.

C. Range and Known Sites

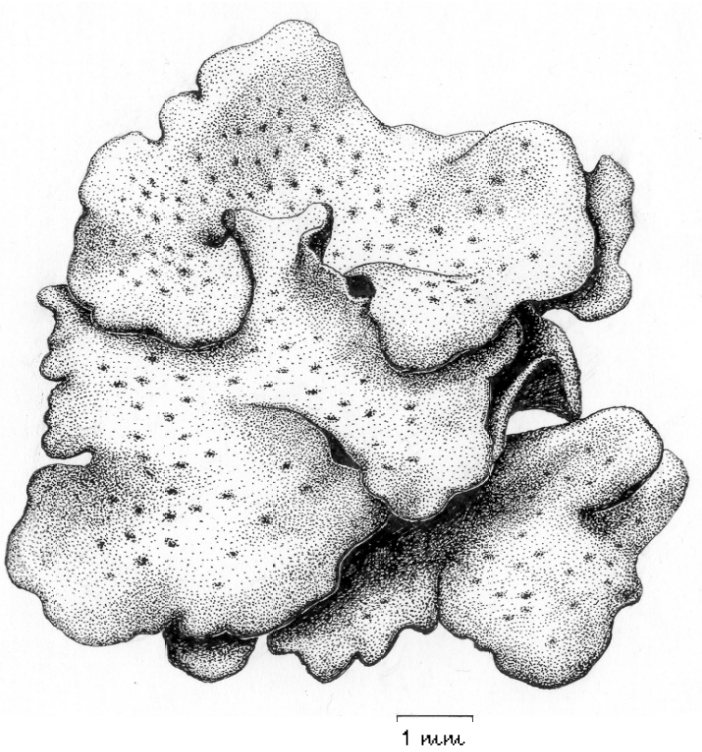

Figure 7. Drawing of *Dermatocarpon luridum*.

D. luridum has rarely been collected in the range of the Northwest Forest Plan, where it is known from only 19 sites. In Washington, it is known from near Tatie Peak, Pacific Crest Trail, Okanogan NF (Okanogan County); on Brown Island (San Juan County) on land of unknown ownership; near Solduc Hot Springs (Clallam County) and Paradise Valley (this site may be in the Olympic NF, but needs confirmation); on the East Fork Lewis River and one of its tributaries, Gifford Pinchot NF (Skamania County); and in Olympic National Park (Jefferson County); and near Vantage (Kittitas County). In Oregon, it is known from Eagle Creek near the fish hatchery, Mt. Hood NF (Clackamas County); near Hog Lake (Lincoln County); on the North Fork Umpqua River (Douglas County); and in the North Fork of Silver Creek, Silver Falls State Park (Marion County). In California, it is known from Marble Mountains Wilderness, Klamath NF (Siskiyou County); near the top of Big Hill on the Hoopa Indian Reservation; and at Hayden Flat Campground (Trinity County) on land of unknown ownership. Globally, *D. luridum* has a broad distribution. It occurs in northern and western Britain and Ireland, in New Zealand (Purvis et al. 1992), and in temperate to arctic regions in the Northern Hemisphere where it is uncommon in the Northwest Territories and frequent throughout British Columbia below the alpine zone (Goward et al. 1994). It is common in eastern North America, and uncommonly collected in the Rocky Mountains (McCune and Geiser 1997), British Columbia (Goward et al. 1994), and southeastern Alaska (Geiser et al. 1998). California sites may represent the southern limits of its range in North America.

D. Habitat Characteristics and Species Abundance

In the range of the Northwest Forest Plan, *D. luridum* grows between 105-1980 m (1000-6500 ft) on rocks, boulders, and bedrock in streams, rivers, or seeps, usually submerged or inundated for most of the year. In larger rivers with high flows, it grows on the sides and downstream edges of in-stream bedrock, where it apparently receives some protection from the direct force of the water. Adjacent riparian vegetation includes red alder *(Alnus rubra)*, Douglas-fir *(Pseudotsuga menziesii)*, western hemlock *(Tsuga heterophylla)* and maple *(Acer* spp.), and subalpine or alpine meadow vegetation. *D. luridum* can be locally abundant, although its distribution in the range of the Northwest Forest Plan is scattered and the species may be rare. The lack of records in our area could be because it is reaching the southern limits of its range and is truly rare, specimens have been misidentified because of taxonomic confusion in the genus, or it has been under-collected.

II. CURRENT SPECIES SITUATION

A. Why Species Is Listed Under Survey and Manage Standard and Guideline

D. luridum was considered at risk under the Northwest Forest Plan because of its rarity and limited distribution in the range of the northern spotted owl (USDA and USDI 1994a). At the time of the FEMAT viability analysis, this species was known from only one site (USDA and USDI 1994a and 1994b).

B. Major Habitat and Viability Considerations

The major viability consideration for *D. luridum* is loss of populations resulting from management activities which harm the populations or affect their habitat.

C. Threats to the Species

Threats to *D. luridum* are those actions that alter water quality—including chemistry, temperature, light regime, level, opacity, or sediment load—or alter microclimatic conditions associated with the riparian vegetation and stream-bank stability. Building and decommissioning roads (including culvert placement and removal) and restoration activities may also pose a threat by directly removing or manipulating occupied substrate or by generating short-term sediment pulses when operating upstream of colonized stream segments. Fertilizer run-off could also threaten some populations. Aquatic ecosystems are particularly responsive to chemical stress because pollutants tend to be well distributed throughout zones of active mixing (Ford 1989). The Hayden Campground site on Shasta Trinity NF is heavily used by recreationists.

D. Distribution Relative to Land Allocations

All known sites of *D. luridum* on federal land within the range of the Northwest Forest Plan are in Riparian Reserves. Several sites, particularly historic ones, are vague and do not have adequate location information. The adjacent land allocations need to be determined.

III. MANAGEMENT GOAL AND OBJECTIVES

A. Management Goal for the Species

The goal for the managing of *D. luridum* is to assist in maintaining species viability.

B. Objectives

Manage known sites on federal lands by maintaining habitat, forest structure, occupied and potential suitable substrate, and micro-climate conditions associated with *D. luridum.*

IV. HABITAT MANAGEMENT

A. Lessons from History

No specific lessons from history about *D. luridum* have been identified.

B. Identifying Habitat Areas for Management

All known sites of *D. luridum* on federal land in the range of the Northwest Forest Plan are identified as habitat areas where these management recommendations should be implemented. A habitat area for management is defined as suitable habitat occupied by or adjacent to a known population.

C. Managing in Habitat Areas

Although *D. luridum* is restricted in its ecological distribution, there may be certain areas where it is locally common. If a population of *D. luridum* occurs in a project area, several factors should be evaluated before proceeding with actions that could adversely impact individuals. Evaluate the importance of that population in relation to other known sites, and the contribution of that population to species viability. Consider the landscape and ecological context of the population, factors such as the location of the population in relation to other known populations, relative isolation of the population, ecological conditions at the site and how they compare to other known sites (typical or atypical), areal extent of the population and abundance of the lichen within the local population, and availability of potentially suitable habitat in the area.

Each local population should be maintained intact, however it may be acceptable to impact a small percentage of known individuals at a particular site if it has only minimal impact to the integrity of the local population. Special consideration should be given to populations near the edge of the range of *D. luridum* and in watersheds where it is rare and of limited distribution.

After evaluating these considerations, and if a decision has been made to impact individuals in a project area, apply the following mitigation measures. Visit the site with a project coordinator to determine if proposed actions can be shifted up or downstream so large concentrations of individuals are not impacted. If impacts are unavoidable, determine if any of the colonized rocks are small enough to be transplanted to suitable habitat above the project area. Transplant as many colonized rocks as possible, and monitor their vigor (Derr 1998).

- Because dispersal may be limited between streams, maintain *D. luridum* in stream where it occurs.
- Determine the extent of local population with a site visit.
- Maintain habitat for the species at known sites on federal lands by maintaining stream conditions including water quality, chemistry, temperature, level, opacity, low sediment levels, and stream-bank stability and maintaining microclimatic conditions (e.g., light regime) associated with the riparian vegetation.
- Reduce sedimentation into populated streams by minimizing impacts of road building, maintenance, restoration, and decommissioning activities, including culvert placement and removal.
- Evaluate upstream activities that could harm downstream populations.
- Evaluate impacts of riparian vegetation treatments, and the potential for altered bank stability, sediment and nutrient input, and how known sites of D. *luridum* could be affected by those activities.
- Avoid the use of fertilizers and herbicides adjacent to populated streams, including upstream reaches.

D. Other Management Issues and Considerations

D. luridum may provide habitat for aquatic invertebrates (USDA and USDI 1994a). Declines in populations could affect ecological functions important to salmon and other components of aquatic and terrestrial ecosystems. *D. luridum is* a good indicator of water quality (USDA and USDI 1994a) and may be sensitive to changes in water chemistry, temperature, light regime, level, opacity, or sediment load.

V. RESEARCH, INVENTORY, AND MONITORING NEEDS

The objective of this section is to identify opportunities to acquire additional information which could contribute to more effective species management. The content of this section has not been prioritized or reviewed as to how important the particular items are for species management. The inventory, research, and monitoring identified below are not required. These recommendations should be addressed by a regional coordinating staff.

Dermatocarpon luridum

A. Data Gaps and Information Needs

- Revisit known sites to verify the status of their populations, determine the extent of the populations and abundance, and characterize habitat conditions.
- Determine the natural range of riparian canopy conditions necessary for survival of *D. luridum.*
- Determine if *D. luridum* meets the criteria for being closely associated with late-successional and old-growth forests.

B. Research Questions

- What are the dispersal rates and mechanisms of *D. luridum?*
- Does this species disperse between streams, and if so, what are the vectors?
- Which habitat characteristics and ecological conditions are necessary for establishing
- *luridum* propagules and survival of established thalli?
- In colonized streams, how does cover of *D. luridum* fluctuate seasonally, annually, or between flood events?
- Can *D. luridum* survive transplanting of colonized rocks to different parts of the parent stream and to different streams?
- How should populations be distributed in a stream to optimize recolonization into lower stream reaches?
- How do *D. luridum* and aquatic insects interact?
- What ecological roles does *D. luridum* play in aquatic and adjacent terrestrial ecosystems?
- Do refugial populations colonize lower stream reaches?

C. Monitoring Needs and Recommendations

- Monitor populations where road building or decommissioning (including culvert removal or placement) or restoration activities occur.
- Monitor streams for dispersal of *D. luridum* where it has been reintroduced.

Erioderma sorediatum

SUMMARY

Species: *Erioderma sorediatum* D.J. Galloway & P.M. Jørg.
Taxonomic Group: Lichens (Rare Oceanic-Influenced)
ROD Components: 1, 3

Other Management Status: The Nature Conservancy Oregon State Rank 1 (critically imperiled because of extreme rarity or because it is somehow especially vulnerable to extinction or extirpation, typically with 5 or fewer occurrences). Oregon Natural Heritage Program Rank 2 (imperiled because of rarity or because other factors demonstrably makes it very vulnerable to extinction (extirpation), typically with 6-20 occurrences). The Nature Conservancy Global Rank 3 (rare, uncommon, or threatened, but not immediately imperiled, typically with 21-100 occurrences) (Oregon Natural Heritage Program 1998). BLM Assessment Status (USDI Bureau of Land Management 1998).

Range: *Erioderma sorediatum* is rare in the range of the northern spotted owl, known from one site in Washington and eight in Oregon. *E. sorediatum* is paleotropical, known from New Zealand and North America, where it is rare from Southeast Alaska through British Columbia, Washington, and Oregon.

Specific Habitat: *E. sorediatum* occurs in the coastal fog zone, and one site in a young, riparian red alder stand about ten miles from the coast. In Oregon, it is found in coastal stabilized dune forests of Sitka spruce and shore pine and interspersed willow/wax myrtle or ericaceous shrub thickets. It is epiphytic on huckleberry, rhododendron, *Arctostaphylos*, and western hemlock. In Washington, it was growing on bark of young red alder.

Threats: The major threat to *E. sorediatum* is loss of local populations resulting from activities that harm the population or impact the habitat, including altering the microclimate and removing colonized substrate. These activities would most likely be related to recreation, such as building trails and shelters, collecting firewood, and off-trail bicycle, off-road vehicle, and foot traffic. As a cyanolichen, it is probably sensitive to air pollution from vehicle exhaust and fire. It is vulnerable to loss of habitat from development along the coast.

Management Recommendations:

- Manage populations at known sites by maintaining ecological conditions associated with *E. sorediatum*, including stand structure, substrate and microclimatic conditions.
- Restrict building, burning, collecting specimens, collecting firewood, operating off-road vehicles and bicycles, and other recreational activities or development that affect colonized substrate and harm known populations.

Information Needs:

- Verify the status of known populations and characterize their ecological conditions.
- Determine if this species meets the criteria for association with late-successional.or old-growth forests.

I. NATURAL HISTORY

A. Taxonomy and Nomenclature

E. sorediatum D.J. Galloway & P.M. Jørg. was described from New Zealand in 1975 (Galloway and Jørgensen 1975).

B. Species Description

1. Morphology and Chemistry

This foliose lichen looks like brownish-gray paint that has dried on the lid of a paint can. The margins of this paint pancake curl up, its lower surface is white, and the upper surface is covered with fine, cottony hairs (**Figure 8**). This species can be confused with *Leioderma sorediatum*, another rare oceanic Survey and Manage lichen, but *E. sorediatum* can be distinguished by the erect tomentum on its upper surface and its PD+ orange reaction (eriodermin) (Tønsberg 1997). It can also be superficially confused with diminutive *Peltigera collina*, but *E. sorediatum* lacks veins below (McCune and Geiser 1997).

Technical description: Thallus foliose, lobate (to 40 mm broad), corticolous. Lobes broad, to 5 mm wide, short, margins ascending, sometimes strongly involute and crenate, developing prominent, bluish, limbiform soralia on the edges of the upturned lower surface of the lobes; soredia coarse, granular, grayish-blue, about 0.1 mm in diameter, often trapped on tomentum of the upper surface and thus becoming spread superficially over the lobes. Upper surface grayish-brown, finely tomentose. Tomentum rather variable in appearance and texture, from a uniform, thin, whitish bloom to a long (to 2 mm) buff or yellowish, tangled or loosely woven mat. Apothecia and pycnidia are not observed. Photobiont is a cyanobacterium. Lower surface white or pale cream, not distinctly yellow. Lower cortex and veins absent; rhizines blue-black, simple to squarrosely branched (to 3 mm long), restricted to margins where they form small dense tufts (Galloway and Jørgensen 1975).

2. Reproductive Biology

E. sorediatum reproduces asexually by producing soredia, which are probably distributed by wind, gravity, animals, or birds (McCune et al. 1997). No sexually reproductive structures are known for this species.

3. Ecological Roles

Little is known about the ecological roles of *E. sorediatum*. *E. sorediatum* is a nitrogen-fixing species, providing a small amount of usable nitrogen to the ecosystems it inhabits. Like other nitrogen-fixing species it is likely to be sensitive to air quality, though its specific sensitivity is unknown.

C. Range and Known Sites

E. sorediatum is rare in the range of the northern spotted owl, known from one site in Washington and eight in Oregon. On the Olympic Peninsula in Jefferson County, Washington, it is found on private land off the Hoh River Road. In Oregon, it is apparently restricted to the extensive dune sheets between Heceta Head and Cape Arago. Oregon sites include Sutton Creek Recreation Area, Siuslaw NF; Clear Lake (McCune et al. 1997); BLM Heceta Dunes Area of Critical Environmental Concern; and T18 R12 Section 35 on land of unknown ownership (Lane County); Lower Canal Creek, Siuslaw NF; T13S R11E Section 2, Siuslaw NF, (Lincoln County); Coos Bay north of North Bend, Siuslaw NF, (Coos County); and Eel Creek Recreation Area, Siuslaw NF (Douglas County) (McCune et al. 1997). *E. sorediatum* has a paleotropical distribution, known from New Zealand and North America, where it is rare from Southeast Alaska (Geiser et al. 1998) through British Columbia, Washington, and Oregon.

D. Habitat Characteristics and Species Abundance

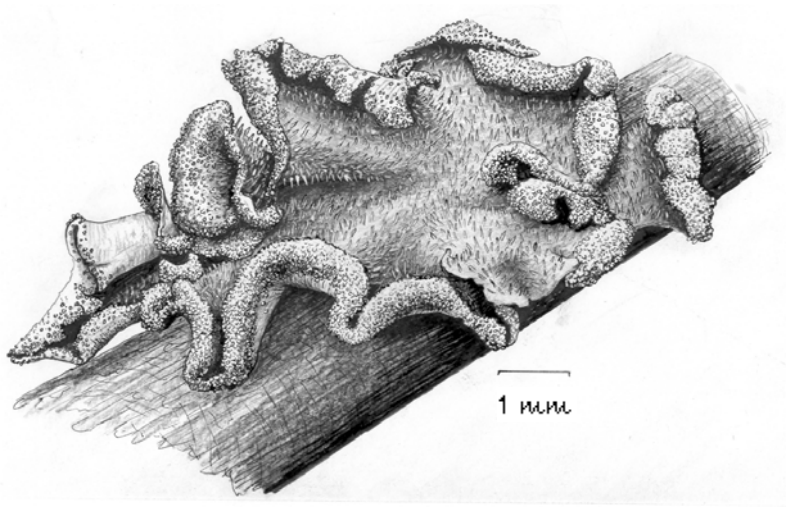

Figure 8. Drawing of *Erioderma sorediatum*.

In Oregon, *E. sorediatum* is found in the coastal fog zone, in broken shore pine (*Pinus contorta*) and Sitka spruce (*Picea sitchensis*) forests interspersed with willow/wax myrtle (*Salix/Myrica*) or ericaceous shrub thickets covering an old system of dune ridges and swales (McCune et al. 1997). It is epiphytic on huckleberry (*Vaccinium*), rhododendron (*Rhododendron macrophyllum*), *Arctostaphylos*, and western hemlock (*Tsuga heterophylla*). In Washington, it grows on the bark of young red alder (*Alnus rubra*) in a riparian area, about 16 km (10 mi) from the coast. This site had an abundance of the cyanolichen *L. oregana*, which is uncommon in young alder stands. The alder stand was next to a large clear-cut, a bridge and a road, and was probably disturbed during road and bridge building (Tønsberg, pers. comm.).

II. CURRENT SPECIES SITUATION

A. Why Species Is Listed Under Survey and Manage Standard and Guideline

E. sorediatum was considered at risk under the Northwest Forest Plan because of its rarity and limited distribution in the range of the northern spotted owl. At the time of the FEMAT viability analysis, this species was known from only three sites within the range of the northern spotted owl (USDA and USDI 1994a and 1994b).

B. Major Habitat and Viability Considerations

The major viability consideration for *E. sorediatum* is loss of sites resulting from management activities that damage the populations or their habitat.

C. Threats to the Species

Threats to *E. sorediatum* are those actions that affect its habitat area, including altering the microclimate and removing colonized substrate, which could result in the loss of individuals and populations. These activities would most likely be related to recreation, such as building trails and shelters, collecting firewood, and off-trail bicycle, off-road vehicle, and foot traffic. It is probably sensitive to air pollution from vehicle exhaust and burning. Collecting specimens may be a threat in populations with low numbers of individuals. It is vulnerable to loss of habitat from construction or clearing along the coast.

D. Distribution Relative to Land Allocations

Several sites of *E. sorediatum* are on BLM land near Heceta Beach, one of which is an Area of Critical Environmental Concern. The species also occurs at two coastal recreation areas on the Siuslaw NF. The Olympic Peninsula site is privately owned.

III. MANAGEMENT GOAL AND OBJECTIVES

A. Management Goal for the Species

The goal for managing *E. sorediatum* is to assist in maintaining species viability.

B. Objectives

Manage known sites on federal lands by maintaining habitat, forest stand structure, occupied and potentially suitable substrate, and microclimatic conditions associated with *E. sorediatum*, and by allowing existing habitat conditions to persist and evolve naturally.

IV. HABITAT MANAGEMENT

A. Lessons From History

No specific historical lessons are known for *E. sorediatum*, but as a nitrogen-fixing lichen it is probably sensitive to air pollution, and in many industrialized parts of the world, nitrogen-fixing lichens have disappeared because of air quality degradation (Rhoades 1988; Ryan and Rhoades 1992; Geiser et al. 1994).

In many parts of the industrialized world, lichens are declining because of habitat alteration (Seaward 1977). *E. sorediatum* habitat is at risk because of development of coastal properties along the Oregon dunes.

B. Identifying Habitat Areas for Management

All known sites of *E. sorediatum* on federal lands within the range of the northern spotted owl are identified as habitat areas where these management recommendations should be implemented. A habitat area for management is defined as suitable habitat occupied by or adjacent to a known population.

C. Managing in Habitat Areas

- Manage known sites on federal land by allowing existing habitat conditions to persist and evolve naturally.
- Firewood collecting should be restricted.
- Collecting voucher specimens should be restricted unless the specimen is found in litterfall.
- Restrict off-trail use of vehicles and bicycles in coastal ericaceous shrub habitats.
- Minimize the extent of shrub and tree clearing along trails during maintenance activities.
- Develop practices to route human use away from the populations (such as diverting trails and roads). The trampling of shrubs, removing trees or branches, introducing non-native species by seed dispersal or planting, compacting of tree or shrub roots which support the species are examples of potential recreational impacts.

D. Other Management Issues and Considerations

Information from reported sites suggests that *E. sorediatum* may not be a species closely associated with late-successional and old-growth forests. For a species to be appropriately listed as a Survey and Manage species, it must first meet the criteria established for designating a species closely associated with late-successional and old-growth forests (USDA and USDI 1994a [Table IV-6] and 1994b). This issue should be addressed by a regional coordinating staff.

In addition to Sutton Creek and Eel Creek, several other federally owned parcels of coastal fog zone habitat with populations of other rare oceanic lichens have similar habitat requirements. These sites are identified as potentially suitable *E. sorediatum* habitat, and should be evaluated for the presence for this species. They are Gwynn Creek and Sand Lake (Siuslaw NF), BLM Heceta Dunes ACEC; a small BLM parcel near Cape Lookout State Park; and a small BLM parcel near Cape Arago and Cape Blanco State Parks.

- Share information with State and private sectors to further activities directed at conservation of *E. sorediatum.*

- Consider opportunities for managing known sites, such as Botanical Special Interest Areas, Areas of Critical Environmental Concern, or other administratively withdrawn designation, or prescribing special standards and guidelines during Forest Plan and Resource Management Plan revisions.
- Request the Oregon and Washington State Natural Heritage Programs track and store information for *E. sorediatum* across all land ownerships.

V. RESEARCH, INVENTORY, AND MONITORING NEEDS

The objective of this section is to identify opportunities to acquire additional information which could contribute to more effective species management. The content of this section has not been prioritized or reviewed as to how important the particular items are for species management. The inventory, research, and monitoring identified below are not required. These recommendations should be addressed by a regional coordinating staff.

A. Data Gaps and Information Needs

- Determine if *E. sorediatum* meets the criteria for being closely associated with late-successional and old-growth forests.
- Revisit known sites to verify the status of known sites, determine the extent of the populations and abundance, and better characterize ecological conditions.
- Determine if *E. sorediatum* occurs in areas identified as potentially suitable habitat. Potentially suitable habitat is identified as foggy coastal deflation dune systems with scattered old Sitka spruce and lodgepole pine forests and ericaceous shrub thickets. Areas with potential suitable habitat include Gwynn Creek Recreation Area and Sand Lake, Siuslaw NF; and BLM parcels adjacent to Cape Lookout, and other coastal BLM parcels. Coastally influenced riparian alder stands could also be potentially suitable habitat.
- Share information with other land management agencies regarding potential suitable habitat in areas such as Cape Lookout, Cape Arago and Cape Blanco State Parks.

B. Research Questions

- What are the dispersal rates and mechanisms of *E. sorediatum*?
- Which habitat characteristics and ecological conditions are necessary for survival of *E. sorediatum* propagules?
- What limits dispersal and establishment of propagules and colonizing of suitable *E. sorediatum* habitat?
- Is *E. sorediatum* sensitive to air pollution?
- Which other rare lichens occur with *E. sorediatum*?
- How do populations of *E. sorediatum* respond to successional changes and associated changes in microclimate?

C. Monitoring Needs and Recommendations

Monitor the effects of recreational activities on populations of *E. sorediatum* in habitat areas.

Erioderma sorediatum

Heterodermia leucomelos

SUMMARY

Species: *Heterodermia leucomelos* Hedw**.**
Taxonomic Group: Lichens (Oceanic-Influenced)
ROD Components: 1, 3

Other Management Status: None

Range: *Heterodermia leucomelos* is known from 16 sites in the range of the northern spotted owl, eight each in Oregon and California; none are on Forest Service or BLM land, although several of the Oregon sites are adjacent to suitable habitat on federal lands. In Oregon, the species occurs in Tillamook, Lane, Coos and Curry Counties; in California it has been found in Humboldt and Marin Counties. Golden Gate National Recreation Area, Marin County, California is the only known site on federal land. In North America, *H. leucomelos* is a coastal species found in California, Oregon and British Columbia.

Specific Habitat: *H. leucomelos* appears to be strictly coastal in the range of the northern spotted owl. In Oregon, it occurs on windswept, forested headlands on large Sitka spruce and possibly shore pine. In California, it grows from sea level to 480 m (1575 ft) in moist coastal redwood forests, in open, low coastal scrub, and in dry, open, savanna-like oak woodlands. Some of these woodlands may be influenced by coastal fog. The species is typically epiphytic but occasionally grows on rocks. In hypermaritime localities of British Columbia, it is infrequent over conifers.

Threats: The major threat to *H. leucomelos* is loss of populations resulting from activities that harm the populations or affect their habitat, including altering microclimate and removing colonized substrate, recreation impacts and collecting specimens. Most populations are known from scattered refugia in state parks along developed coastal areas in Oregon and California.

Management Recommendations:

- Manage populations at known sites by maintaining ecological conditions associated with *H. leucomelos*, including stand structure, substrate, and microclimatic conditions.
- Restrict building, burning, collecting specimens and firewood, and any other recreational activities or development that could harm known populations.

Information Needs:

- Verify the status of known populations of *H. leucomelos* and characterize their ecological conditions.
- Determine if *H. leucomelos* meets the criteria for being closely associated with late-successional and old-growth forests.
- Locate additional populations of *H. leucomelos* in potentially suitable habitats on federal land along the immediate Oregon coast.

I. NATURAL HISTORY

A. Taxonomy and Nomenclature

H. leucomelos (L.) Poelt was described in 1965.

Synonym:
Anaptychia leucomelaena

B. Species Description

1. Morphology and Chemistry

This foliose lichen forms loose rosettes of narrow lobes with long gray or black cilia (**Figure 9**). The white, ascending, extended lobes and long, marginal, often intertwined dark cilia are characteristic. Soredia development is variable; when present, they develop on the distal portion of the underside, which is strongly reflexed and exposed by upward curling of the lobes (Purvis et al. 1992). It could be confused with a wide-lobed *Physcia tenella,* but that species is PD- and is often apotheciate.

Technical Description: Thallus 5-15 cm across, often in loose rosettes forming entangled mats, more or less loosely attached; lobes 0.5-3 mm wide, elongate, mostly dichotomously branched, entangled, sometimes ascending at the tips, sometimes reflexed, with conspicuous, long, gray or black, simply or sparsely branched to squarrosely branched marginal cilia, 5-9 mm long; upper surface ivory white, smooth; lower surface white, channeled, central part arachnoid or powdery and somewhat sorediate; lower cortex not developed. Apothecia not observed. Medulla PD+ yellow, K+ yellow-red, KC+ yellow-red, C- (Purvis et al. 1992).

2. Reproductive Biology

This species reproduces asexually by producing soredia that may be distributed by wind, gravity, animals, or birds. No sexually reproductive structures are known for *H. leucomelos*.

3. Ecological Roles

Little is known about the ecological roles of *H. leucomelos*. This species is used as nesting material by bushtits.

C. Range and Known Sites

In the range of the northern spotted owl, *H. leucomelos* is known from 16 sites, eight in Oregon and eight in California. None of these sites are on Forest Service or BLM land, although several of the Oregon sites are adjacent to suitable habitat on Forest Service and BLM land. In Oregon, it occurs in Tillamook, Lane, Coos and Curry Counties. In California it is found in Humboldt and Marin Counties. Golden Gate National Recreation Area in Marin County, California, is the only known site on federal land. In North America, *H. leucomelos* is a coastal species in California, Oregon, and British Columbia. In Oregon, the species is present at Cape Lookout State Park and near Sand Lake on land of unknown ownership (McCune et al. 1997) (Tillamook County), at Heceta Head State Scenic Viewpoint (Lane County), at Cape Blanco and Cape Sebastian State Parks, and 1 km (0.6 mi) south of Brookings at an unspecified site (McCune et al. 1997) (Curry County), at Cape Arago State Park (Coos County), and at Natural Bridge Cove Scenic Point (McCune et al. 1997). In California, it is found at eight sites: the Samoa Peninsula, Trinidad State Beach, Lanphere Dunes Unit (Humboldt Bay National Wildlife Refuge, USFWS), near Ferndale, at Clam Beach Vista Point near McKinleyville, and Patrick's Point State Park (Humboldt County), and Tomales Bay State Park and Golden Gate National Recreation Area (Marin County).

The range of *H. leucomelos* is incompletely circumpolar; it is found in the Americas, England, Europe, Africa, and Asia, and is widespread in the tropics and subtropics. In North America it is known from coastal British Columbia (Goward et al. 1994), coastal Oregon, and coastal California.

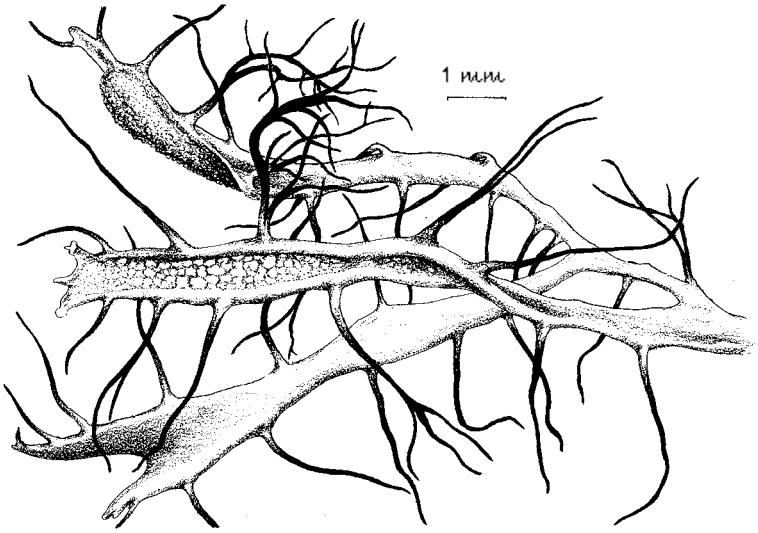

Figure 9. Drawing of *Heterodermia leucomelos.*

D. Habitat Characteristics and Species Abundance

In Oregon, *H. leucomelos* grows on small branches of Sitka spruce (*Picea sitchensis*) on forested headlands in the coastal fog zone, and it may also grow on shore pine (*Pinus contorta*) in this habitat. In California, it grows on the trunks and branches of Sitka spruce, on oaks (*Quercus*) and other broad-leaved trees and shrubs, and occasionally on rocks, from sea level to 480 m (1575 ft). It was also found incorporated into a bushtit nest. The species is found in several California habitats, including moist, coastal redwood forests; open, low coastal scrub; and dry, open, savanna-like valley and foothill woodlands dominated by California oak species (Hale and Cole 1988). In British Columbia, it is infrequent on conifers in open hypermaritime localities (Goward et al. 1994). In Europe— where it is rare, local, and declining—*H. leucomelos* is found on mossy rocks or moss-lichen turf on sunny, exposed, coastal cliffs, and rarely on trunks and branches of wayside, broad-leaved trees (Purvis et al. 1992).

In the range of the northern spotted owl, *H. leucomelos* appears to be rare and confined to a narrow coastal habitat. This species might also be found at inland sites with coastal influences or conditions, such as riparian areas, moist valleys, and fog-intercept ridges.

II. CURRENT SPECIES SITUATION

A. Why Species Is Listed Under Survey and Manage Standard and Guideline

H. leucomelos was considered at risk under the Northwest Forest Plan because of its rarity and limited distribution in the range of the northern spotted owl. At the time of the FEMAT viability analysis, this species was known from five sites in the range of the northern spotted owl (USDA and USDI 1994a,b).

B. Major Habitat and Viability Considerations

The major viability consideration for *H. leucomelos* is loss of populations resulting from management activities that harm the populations or alter their habitat.

C. Threats to the Species

Threats to *H. leucomelos* are actions that disrupt stand conditions necessary for its survival, including treatments that harm local populations by removing coastal Sitka spruce and other colonized substrates; alter the light, moisture, or temperature regime; or degrade air quality. Recreation-related activities such as building trails and shelters and collecting firewood could adversely affect populations, as well as

collecting of specimens. Because this species is apparently restricted to the immediate coast, particularly in Oregon, altering potentially suitable habitat could inhibit establishment. This species is vulnerable to loss of habitat because of increasing development along the coast.

D. Distribution Relative to Land Allocations

Currently, *H. leucomelos* is not known from Forest Service or BLM land in the range of the northern spotted owl, although there is potentially suitable habitat.

III. MANAGEMENT GOAL AND OBJECTIVES

A. Management Goal for the Species

The goal for managing *H. leucomelos* is to assist in maintaining species viability.

B. Objectives

Manage known sites on federal lands by maintaining habitat, forest structure, occupied and potentially suitable habitat, and micro-climate conditions associated with *H. leucomelos*.

IV. HABITAT MANAGEMENT

A. Lessons From History

The importance of lichens in forested and other habitats is recognized globally. Conversion of old-growth forests into young managed stands leads to a significant reduction in epiphytic lichen biomass, which in turn will probably affects nutrient cycling in forests and may have negative consequences for animals that use canopy lichens as food, shelter, or nesting material (Esseen 1996). In the range of the northern spotted owl, bushtits use *H. leucomelos* as nesting material.

B. Identifying Habitat Areas for Management

All known sites of *H. leucomelos* on federal lands in the range of the northern spotted owl are identified as habitat areas where these management recommendations should be implemented. A habitat area for management is defined as suitable habitat occupied by or adjacent to a known population.

C. Managing in Habitat Areas

- Manage habitat areas on federal land by allowing existing habitat conditions to persist and evolve naturally.
- Restrict firewood collection.
- Restrict collecting voucher specimens for scientific purposes, unless they are found in litterfall. Restrict off-road vehicles, bicycle and foot traffic in coastal ericaceous shrub habitats without trails.
- Minimize the extent of the clearing of shrubs and trees along trails during maintenance activities. Develop practices to route human use away from the populations (e.g., divert trails and roads). Trampling of shrubs, removing of trees or branches, introducing non-native species by seed dispersal or planting, compacting tree or shrub roots which support the species, are all examples of potential recreational impacts.

D. Other Management Issues and Considerations

Information from reported sites suggests that *H. leucomelos* may not be a species closely associated with late-successional and old-growth forests. For a species to be appropriately listed as a Survey and Manage species, it must first meet the criteria established for designating a species as closely associated with late-successional and old-growth forests (USDA and USDI 1994a [Table IV-6] and 1994b). This issue should be addressed by a regional coordinating staff.

- Share information with state and private sectors to further activities directed at the conservation of *H. leucomelos.*
- Request the Oregon and Washington State Natural Heritage Programs track and store information for *H. leucomelos* across all land ownerships.

V. RESEARCH, INVENTORY AND MONITORING NEEDS

The objective of this section is to identify opportunities to acquire additional information which could contribute to more effective species management. The content of this section has not been prioritized or reviewed as to how important the particular items are for species management. The inventory, research, and monitoring identified below are not required. These recommendations should be addressed by a regional coordinating staff.

A. Data Gaps and Information Needs

There are several federal parcels of coastal fog zone habitat with populations of other rare oceanic lichens with similar habitat requirements as *H. leucomelos*. These sites are identified as potential suitable *H. leucomelos* habitat, and should be evaluated for the presence for this species. They are Sutton Creek and Eel Creek, Gwynn Creek and Sand Lake (Siuslaw NF), BLM Heceta Dunes Area of Critical Environmental Concern; a small BLM parcel near Cape Lookout State Park, and other coastal BLM parcels.

- Determine if *H. leucomelos* meets the criteria for being closely associated with late-successional and old-growth forest established in FEMAT.
- Revisit known sites to verify the status of known populations, determine the extent of the populations and abundance, and to characterize habitat conditions.
- Determine the land ownership of the population on the Samoa Penisula.

B. Research Questions

- What are the dispersal rates and mechanisms of *H. leucomelos*?
- Which habitat characteristics and ecological conditions are necessary for survival of *H. leucomelos* propagules?
- What limits dispersal and establishment of propagules and colonization of suitable *H. leucomelos* habitat?
- Is *H. leucomelos* sensitive to air pollution?
- Which suites of other rare lichens are found with *H. leucomelos*?
- How do populations of *H. leucomelos* respond to successional changes and associated changes in microclimate?

C. Monitoring Needs and Recommendations

Monitor the effects of recreational activities on populations of *H. leucomelos* in habitat areas.

Heterodermia leucomelos

Hydrothyria venosa

SUMMARY

Species: *Hydrothyria venosa* J. L. Russell
Taxonomic Group: Lichens (Aquatic)
ROD Components: 1, 3

Other Management Status: None

Range: In the range of the Northwest Forest Plan, *Hydrothyria venosa* is known from 53 sites, 28 in Washington and 25 in Oregon, all on federal land. In Washington, it is known from Mt. Baker-Snoqualmie NF; Mt. Rainier National Park; Olympic National; and the Gifford Pinchot NF, and Carson National Fish Hatchery. In Oregon, it is known from Willamette NF; Mt. Hood NF; Deschutes NF; Siuslaw NF; and Crater Lake National Park *H. venosa* is a North American endemic occurring in all major mountain ranges, where it is uncommon.

Specific Habitat: This aquatic lichen grows primarily on rocks ranging from small gravel to bedrock, and occasionally on wood submerged in small, clear, cold mountain streams between 1150-7000 ft (350-2133 m) elevation. It has also been reported from concrete head boxes at a fish hatchery, and on the inside lip of a galvanized culvert. It is occasionally found on exposed rocks above low flow levels, where hydration from splash and humidity are high. While it can be abundant in some streams, it is often absent from streams with suitable habitat.

Threats: Potential threats may be actions that alter stream conditions, including water quality, chemistry, temperature, light regime, level, opacity, or sediment levels; reduce streambank stability; or change the micro-climate conditions associated with riparian vegetation. Road building, restoration and decommissioning activities, including culvert placement and removal, and fish habitat enhancement projects involving instream structures are also threats. Activities at sites upstream could affect downstream populations.

Management Recommendations:

- Because dispersal may be limited between streams, maintain *H. venosa* in each stream where it occurs.
- Maintain stream conditions necessary for survival of *H. venosa*.
- Evaluate effects of treating riparian vegetation on populated stream reaches.

Information Needs:

- Determine if *H. venosa* meets the criteria for close association with late-successional and old-growth forests.
- Determine the ranges in stream conditions necessary for survival of *H. venosa*.
- Determine the natural range of riparian canopy conditions necessary for survival.
- Determine mechanisms and rates of reproduction, dispersal distance and growth.

I. NATURAL HISTORY

A. Taxonomy and Nomenclature

Hydrothyria venosa J.L. Russell was described by Russell in 1856 (Proc. Exxes. Sust. 1:188-191).

B. Species Description

1. Morphology and Chemistry

H. venosa is a non-stratified, or gelatinous lichen with cyanobacteria scattered throughout the thallus. The thallus consists of dark, lead-colored to brown or blackish, tufted suberect medium-sized (about 2 cm) lobes, with distinct brownish veins on the underside and small- to medium-sized pinkish apothecia sessile on the upper surface (**Figure 10**). It is the only gelatinous lichen with distinct veins, and is the largest strictly aquatic lichen in the area. It occurs in small, cold, clear streams where it appears in dark, ruffled masses. Ear lobe-like discs of non-lichenized *Nostoc* (the cyanobacterium also occurs in *H. venosa*) are often present on submerged rocks in *H. venosa* habitat, but are more jelly-like and non-veined (McCune and Geiser 1997).

Technical Description: Thallus foliose, gelatinous (non-stratified), medium-sized, lead-colored to brownish or blackish, loosely lobed, the lobes fan-shaped, lobes irregularly cut, obtusely crenate towards the margins, tufted and suberect; bearing prominent brown branched veins below; apothecia small to medium size, 0.75-3.5 mm across, sessile and submarginal, the disk flat to convex, brown to reddish-brown, the exciple becoming torn-dentate and disappearing; spores fusiform-ellipsoid, 24-32 x 7-8.5 µm, 8 per ascus, 3-septate; photobiont short chains of *Nostoc* scattered throughout the medulla; spot tests negative (Fink 1935:171).

2. Reproductive Biology

H. venosa reproduces sexually by producing fungal spores in apothecia. Because the species is aquatic, the spores are probably distributed primarily by flowing water. Aquatic invertebrates that graze on this lichen and ingest spores could also be dispersal vectors, as could dippers and other birds, and the downstream movement of colonized rocks. The species also reproduces by thallus fragmentation as water turbidity increases and pieces of thalli drift downstream.

3. Ecological Roles

Little is known about the ecological roles of this freshwater lichen. It fixes nitrogen and contributes an unknown amount of nitrogen to aquatic ecosystems. The species may provide forage and cover for some aquatic invertebrates, which in turn are food for fish. Many invertebrates, including protozoans, nematodes, rotifers and tardigrades, use aquatic lichens as food and habitat (Gerson and Seaward 1977). *Leptogium rivale*, another nitrogen-fixing aquatic lichen, is often present at the same sites as *H. venosa*. These lichens share the same photobiont, the cyanobacterium *Nostoc*, which is often present in its free-living form in streams with both lichen species. The relation between these three species is unknown. Aquatic lichens are presumed to be good indicators of water quality (USDA Forest Service and USDI 1994b).

C. Range and Known Sites

In the range of the Northwest Forest Plan, *H. venosa* is known from 53 sites, 28 in Washington and 25 in Oregon, where it is almost exclusively montane. All sites are on federal lands. In Washington, it is known from the Mt. Baker-Snoqualmie NF (Whatcom and Snohomish Counties); Mt. Rainier National

Park (King and Pierce Counties); Olympic National Park (Clallam and Jefferson Counties); and the Gifford Pinchot NF and Carson National Fish Hatchery (Skamania County). In Oregon, it is known from Willamette NF (Lane, Marion and Linn Counties); Mt. Hood NF (Marion, Clackamas and Hood River Counties); Deschutes NF (Deschutes, Lane and Jefferson Counties); Siuslaw NF (Lane County); and Crater Lake National Park (Klamath County). Although it is present in the California Sierras, those sites are outside the range of the Northwest Forest Plan. *H. venosa* is a North American endemic found in all major mountain ranges (McCune and Geiser 1997). In the Pacific Northwest it ranges from the California Sierra Nevada Mountains to Southeast Alaska (Geiser *et al*. 1998).

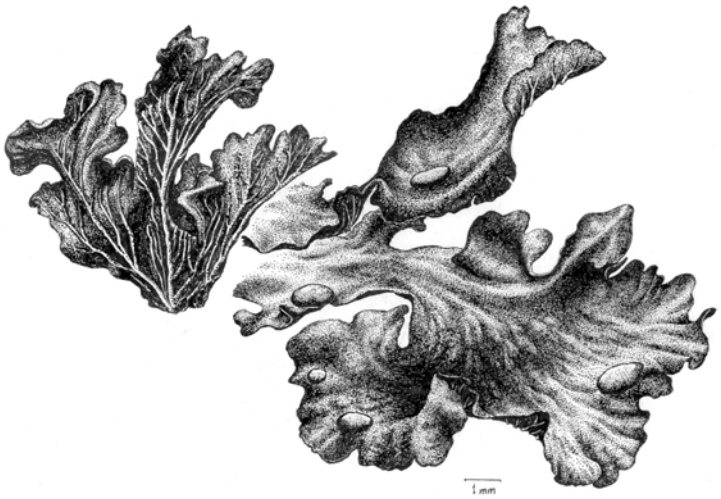

Figure 10. Drawing of *Hydrothyria venosa.*

D. Habitat Characteristics and Species Abundance

H. venosa grows in clear flowing mid- to high-elevation streams where water quality appears to be very good (Dennis et al. 1981). This aquatic lichen grows primarily on small to medium rocks or bedrock and occasionally on wood, or partially buried in loose gravel in small, cool, clear perennial streams between 1150-7000 ft (350-2133 m) elevation. It is also known from one site where it grows on the concrete head box walls of a fish hatchery that has constantly circulating cold water, and a few small thalli were found on the inside of a culvert where light is high. It is never abundant on the culverts. It is occasionally found on exposed rocks above low water levels, and can survive periodic desiccation in sites with high humidity. At sites where *H. venosa* occurs, it can be abundant. This species is considered to be uncommon throughout its range, which could reflect limited dispersal between streams, narrow habitat requirements, and/or the few lichen surveys, which have typically focused on terrestrial habitats.

An informal survey of the H.J. Andrews Experimental Forest suggested that water quality, stream gradient, and substrate may be more important factors than canopy cover and forest age in determining presence of *H. venosa* (Daly 1991). It was not found in streams with gradients greater than 20%, or in higher gradient stream reaches in colonized streams, presumably because of the increased friction and turbulence of flow in steeper-gradient streams, and it was not found in many streams that appeared to be suitable habitat, suggesting that dispersal mechanisms between different streams are limited (Daly 1991). Dispersal vectors are unknown, although flowing water, birds such as dippers, and aquatic insects are presumed to aid in dispersal. Bill Davis, a doctoral student at Arizona State University is studying the ecophysiology and habitat characteristics of *H. venosa* and other aquatic lichens (Davis, 1995), which will increase our knowledge about this species.

II. CURRENT SPECIES SITUATION

A. Why Species is listed under Survey and Manage Standard and Guidelines

H. venosa was thought to be at risk under the Northwest Forest Plan because of its rarity and limited distribution in the range of the northern spotted owl. At the time of the FEMAT viability analysis, this species was known from 21 sites (USDA and USDI 1994a,b).

B. Major Habitat and Viability Considerations

The major viability consideration for *H. venosa* is loss of populations resulting from management activities that harm the local populations or affect their habitat.

C. Threats to the Species

Threats to *H. venosa* are those actions that alter stream conditions including water quality, chemistry, temperature, light regime, level, opacity, or sediment load, or reduce stream-bank stability, or alter microclimatic conditions associated with the riparian vegetation. Fish habitat enhancement projects that involve placement of instream structures that affect local populations are a threat. Building and decommissioning roads (including culvert placement and removal) and restoration activities may also pose a threat by directly removing or manipulating occupied substrate or by generating short-term sediment pulses when operating upstream of colonized stream segments. Run-off from fertilizers could also threaten local populations. Aquatic ecosystems are particularly responsive to chemical stress because pollutants tend to be well distributed throughout zones of active mixing (Ford 1989).

D. Distribution Relative to Land Allocations

All known sites of *H. venosa* are in Riparian Reserves (USDA and USDI 1994c). The adjacent land allocations need to be determined.

III. MANAGEMENT GOAL AND OBJECTIVES

A. Management Goal for the Species

The goal for managing *H. venosa* is to assist in maintaining species viability.

B. Objectives

Manage known sites on federal land by maintaining habitat, stream conditions, riparian forest structure, occupied and potential suitable substrate, and microclimatic conditions associated with *H. venosa*.

IV. HABITAT MANAGEMENT

A. Lessons From History

H. venosa is known from the four major mountain chains in the United States and southern Canada (McCune and Geiser 1997). Most Appalachian Mountain populations have been extirpated, probably by habitat degradation (Dennis et al. 1981). Because many invertebrates may use this species and other aquatic lichens as food and habitat (Gerson and Seaward 1977), declines in aquatic lichens could impact these invertebrates which in turn provide food and nutrients to other components of aquatic and terrestrial ecosystems. Water quality has probably negatively affected this species at some sites. The sensitivity of lichens to air pollution is well documented. *H. venosa*, like other nitrogen-fixing lichens, is probably sensitive to ozone, sulfur dioxide, nitrous oxides, and other air pollutants (Ryan and Rhoades 1992). A transplant experiment of *H. venosa* and subsequent monitoring have been conducted to mitigate road decommissioning activities on the Gifford Pinchot NF (Derr 1998). Surveys in 1995 revealed individuals that were growing above and below culverts scheduled for removal, which prompted several questions: Could *H. venosa* be transplanted upstream? Would the transplants survive? How could transplant growth be monitored? To answer these questions, twenty colonized rocks in two different streams were carried to shallow pools above the culverts, and the lichen surface area on these transplants was monitored for two years. Nearly all transplants showed increases in lichen surface area after 13 months, in one case as high as 320% (Derr 1998). Only one transplant experienced a decline in surface area because the rock had flipped over, killing the lichen. These results suggest that transplantation and lichen surface area monitoring may be an appropriate mitigation for *H. venosa*.

B. Identifying Habitat Areas for Management

Known sites of *H. venosa* on federal land administered by the Forest Service and BLM within the range of the Northwest Forest Plan are identified as habitat areas where these management recommendations should be implemented. Habitat areas are defined as suitable habitat occupied by or adjacent to a known site.

C. Managing in Habitat Areas

Although *H. venosa* is restricted in its ecological distribution, there may be certain areas where it is locally common. If a population of *H. venosa* occurs in a project area, several factors should be evaluated before proceeding with actions that could adversely affect individuals. Evaluate the importance of that population in relation to other known sites, and the contribution of that population to species persistence. Consider the landscape and ecological context of the population, factors such as the location of the populations in relation to other known populations, relative isolation of the population, ecological conditions at the site and how they compare to other known sites (typical or atypical), areal extent of the population and abundance of the lichen within the local population, and availability of potentially suitable habitat in the area.

Each local population should be maintained intact, however it may be acceptable to impact a small percentage of known individuals at a particular site if it has only minimal affect on the integrity of the local population. Special consideration should be given to populations near the edge of range of *H. venosa*, in watersheds where it is rare and of limited distribution.

After evaluating these considerations, and if a decision has been made to impact individuals in a project area, apply the following mitigation measures. Visit the site with a project coordinator to determine if proposed actions can be shifted upstream or downstream so large concentrations of individuals are not affected. If impacts are unavoidable, determine if any of the colonized rocks are small enough to be transplanted to suitable habitat above the project area. Transplant as many colonized rocks as possible, and monitor their vigor (Derr 1998). About a year after the project is completed, and most sediment has flushed downstream, relocate transplants below the project site.

- Because dispersal may be limited between streams, maintain *H. venosa* in stream where it occurs.
- Determine the extent of local population with a site visit.
- Maintain habitat for the species at known sites on federal lands by maintaining stream conditions including water quality, chemistry, temperature, level, opacity, and low sediment levels, and maintaining stream-bank stability and microclimatic conditions (e.g., light regime) associated with the riparian vegetation.
- Reduce sedimentation into populated streams by minimizing or avoiding impacts of road building, maintenance, restoration, and decommissioning activities, including culvert placement and removal.
- Evaluate upstream activities that could harm downstream populations.
- Evaluate effects of treatments to riparian vegetation and the potential for altered bank stability, sediment and nutrient input, and how known sites of *H. venosa* could be affected by those activities.
- Avoid the use of fertilizers and herbicides next to populated streams, including upstream reaches.

D. Other Management Issues and Considerations

Because *H. venosa* may provide habitat for aquatic invertebrates (USDA and USDI 1994a), its declines could impact ecological functions and food web relationships important to fish and other components of aquatic and terrestrial ecosystems. *H. venosa* fixes nitrogen and contributes an unknown amount of nitrogen to aquatic ecosystems; removing a local population could have unknown effects on the nutrient cycles of the stream. This species is a good indicator of water quality (USDA and USDI 1994a) and can be sensitive to changes in water chemistry, temperature, light regime, level, opacity, or sediment load. Known sites should be evaluated at the sub-basin scale because activities far from the site may adversely affect it if they alter upper reaches of the stream. If *H. venosa* is in a project area, evaluate its distribution and abundance in a particular stream. If the species is well-distributed in the stream above a project area, evaluate suitable habitat below the project area, and the likelihood that *H. venosa* will be able to repopulate areas affected by management activity. The highest priority should be given to those sites where management activities may alter stream hydrology or aquatic conditions.

V. RESEARCH, INVENTORY, AND MONITORING NEEDS

The objective of this section is to identify opportunities to acquire additional information that could contribute to more effective species management. The content of this section has not been prioritized or reviewed as to how important the particular items are for species management. The inventory, research,

and monitoring identified below are not required. These recommendations should be addressed by a regional coordinating staff.

A. Data Gaps and Information Needs

- Revisit a representative sample of known sites to verify their status, determine extent and abundance of individuals in a stream, and characterize ecological conditions.
- Determine if *H. venosa* meets the criteria for being closely associated with late-successional and old-growth forests.
- Determine the natural range of riparian canopy conditions necessary for survival of *H. venosa*.

B. Research Questions

- Do individuals scattered along the length of a stream comprise more than one local population?
- Conduct genetic studies to determine if individuals scattered along the length of a stream represent more than one local population.
- What are the dispersal rates, distances, and mechanisms of *H. venosa*?
- Which habitat characteristics and ecological conditions are necessary for establishment of propagules and survival of established thalli?
- What are the seasonal, annual, or between-flood-event fluctuations in cover of *H. venosa* in a colonized stream?
- How could individuals be distributed in a stream to optimize recolonization into lower stream reaches?
- How do *H. venosa* and aquatic insects interact?
- What ecological roles does *H. venosa* play in aquatic and adjacent terrestrial ecosystems?
- What is the genetic relation between *H. venosa*, *Leptogium rivale*, and *Nostoc* in the same stream? How do these species interact?
- Do upstream populations of *H. venosa* colonize lower stream reaches?

C. Monitoring Needs and Recommendations

- Monitor sites of restoration activities, where roads are built or decommissioned, and culverts are removed or placed.
- Monitor transplanted populations for changes in surface area, biomass, and vigor.
- Monitor streams for dispersal of *H. venosa* where it has been reintroduced.

Hypogymnia duplicata

SUMMARY

Species: *Hypogymnia duplicata* (Ach.) Rass.
Taxonomic Group: Lichens (Rare Leafy)
ROD Components: 1, 2, 3

Other Management Status: none

Range: *Hypogymnia duplicata* is endemic to the Pacific Northwest and ranges from Prince William Sound in Alaska south to northwestern Oregon. On federal land in Washington, it is known to occur in Mt. Baker-Snoqualmie and Olympic NFs, and Olympic National Park. In Oregon it is known to occur in Mt. Hood and Siuslaw NFs and Salem District BLM.

Specific Habitat: *H. duplicata* has a fairly narrow ecological amplitude. It grows as an epiphyte on mountain hemlock, western hemlock, Pacific silver fir, Douglas-fir and subalpine fir in old-growth forests of the western Cascades, Olympics and Coast Range, primarily between 330-1660 m (1100-5450 ft) elevation. In the western North Cascades, *H. duplicata* is found in high precipitation areas in old-growth mountain hemlock/Pacific silver fir forests in the moist to mesic Alaska huckleberry plant associations. Habitat for Oregon populations is noted as moist hemlock stands, true fir forests, moss-covered basalt outcrops and snags in a bog.

Threats: The main threat to *H. duplicata* is loss of populations due to activities that affect the habitat or the population, including removal of colonized substrate and alteration of microclimate. Declining air quality may be a threat to populations if it is determined that *H. duplicata* is sensitive to air pollution. A warming climate may stress populations at the limits of this species' range, and could result in a decline in vigor and a more restricted distribution of *H. duplicata*.

Management Recommendations:

- Manage populations at known sites by maintaining the ecological conditions associated with *H. duplicata* including forest structure, substrate and microclimate.
- Restrict thinning or other stand treatments that will alter stand microclimate.
- Prevent fire in the habitat areas with emphasis on fire suppression.

Information Needs:

- Verify current status of known populations; determine the distribution of populations, species abundance and ecological requirements of *H. duplicata* in the area of the Northwest Forest Plan.
- Determine the air pollution sensitivity of *H. duplicata*.

I. NATURAL HISTORY

A. Taxonomy and Nomenclature

H. duplicata (Ach.) Rass was originally described (as *Parmelia*) by Acharius.
This species is in the order Lecanorales, suborder Lecanorineae, family Parmeliaceae (Tehler 1996).

Synonym:
Hypogymnia elongata (*fide* Goward).

B. Species Description

1. Morphology and Chemistry

H. duplicata is a medium-sized foliose lichen with hollow, narrow lobes. The thallus is pendulous and its branches form a cascade of curved lobes. The lobes are narrow, typically uniform in width, 1-2 mm wide, and characteristically turn up at the lobe tips (**Figure 11**). The upper surface is grayish-white, lower surface is black and without rhizines (root-like holdfasts); lobe interior usually white; apothecia uncommon.

Technical description: thallus foliose, medium-sized to large (mostly 4-20 [30] cm), whitish-gray to greenish-gray above; lobes nodulose, hollow, about 1 mm wide, cascading in arcs, somewhat turned up at the lobe tips; lobe interiors usually white, or with a dark floor and white ceiling; lower cortex surface black; apothecia uncommon; soredia and isidia lacking; cortex K+ yellow; medulla K-, KC-, PD+ red, (Goward *et al*. 1994, McCune and Geiser 1997). Contains atranorin, diffractaic, physodalic and protocetraric acids (Goward *et al*. 1994)

There are similar species of *Hypogymnia* that may be confused with *H. duplicata.*

- *H. inactiva* typically has erect, broader and shorter thallus lobes, with dichotomous branching, and a pale to dark but never white medulla. Chemistry: cortex K+ yellow, medulla PD-, KC+ red.
- *H. imshaugii* also has shorter thallus lobes which are typically stiff and erect, not cascading as in *H. duplicata*; the medulla in *H. imshaugii* is white as in *H. duplicata*. Chemistry: cortex K+ yellow, medulla KC+ red, PD+ red (or PD-).
- *H. apinnata* and *H. enteromorpha* may have drooping thallus lobes, although they are typically broad (2-5 mm) and irregular in width, sometimes nodulose, compared with the consistently narrow (1 mm) lobes in *H. duplicata*; the medulla in *H. apinnata* and *H. enteromorpha* are pale to dark but never white. Chemistry: *H. apinnata*— all chemical tests for the medulla are negative, cortex is K+ yellow; *H. enteromorpha*— cortex is K+ yellow, medulla is PD+ orange or red, KC+ red.

2. Reproductive Biology

Apothecia are uncommon in *H. duplicata*; soredia and isidia are lacking. This species may also reproduce vegetatively by fragmentation.

3. Ecological Roles

Little is known specifically about the ecological roles of *H. duplicata.* Various ecological functions of this species may be inferred by noting in general the ecosystem functions of lichens, which include their role as primary producers, their contributions to nutrient cycling by way of accumulating nutrients in their thalli which are then released by decomposition or consumption. Lichen litterfall contributes organic material to the soil. This species may contribute to the food web by providing forage for various organisms, possibly including invertebrates, small mammals, and ungulates. Invertebrates may also use the lichen thalli for shelter and possible nesting sites, as has been observed in some *Hypogymnia* species; e.g., *H. enteromorpha*.

C. Range and Known Sites

H. duplicata is endemic to the Pacific Northwest, ranging from Prince William Sound in Alaska south to Oregon. Most of the known sites are on federal land with the majority occurring on the Mt. Baker-Snoqualmie NF. In Washington, this species is known from Whatcom, Skagit, Snohomish, King, Lewis, Clallam, Mason, and Grays Harbor Counties, and in Oregon from Clackamas, Multnomah, Hood River, Clatsop, Lincoln, Polk, Tillamook, Yamhill, and Lane Counties. Known sites on federal lands in Washington include Mt. Baker, Sulphur Creek Lava Flow, Finney Block, Boulder River Wilderness, Suiattle River valley, upper Sauk River, Goodman Creek, Barlow Pass, South Fork Stillaguamish River, Mt. Pilchuck area, Canyon Creek near Verlot, Silverton area, Barclay Lake, Martin Creek in the Tye watershed, Miller River, Mt. Persis, Alpine Lakes Wilderness, Snoqualmie River drainage, Snoqualmie Pass area, and the Cedar River watershed, all on the Mt. Baker-Snoqualmie NF. On the Olympic Peninsula, it is known from the Skokomish River drainage on Olympic NF; and the Solduc River Valley and Staircase area in Olympic National Park. *H. duplicata* is not known in Washington on federal land south of the Cedar River watershed. Known sites on federal land in Oregon include Zigzag, Estacada, and Hood River Ranger Districts on the Mt. Hood NF; Columbia River Gorge National Scenic Area; Salem District BLM Lost Prairie Area of Critical Environmental Concern (ACEC), North Fork Siletz River near Valley of the Giants, Saddlebag (Saddleback) Mountain ACEC and Bald Mountain east of Tillamook; Hebo Ranger District (Yamhill and Tillamook Counties) and Mt Hebo on the Siuslaw NF. Known sites on non-federal land include Mt. Pilchuck area (Washington State Department of Natural Resources, Snohomish County), Forest Health Monitoring Plot (private land, Lewis County), and Twin Harbors State Park (Grays Harbor County) in Washington; Saddle Mountain State Park (Clatsop County), and Neahkanie Mountain (Tillamook County) in Oregon.

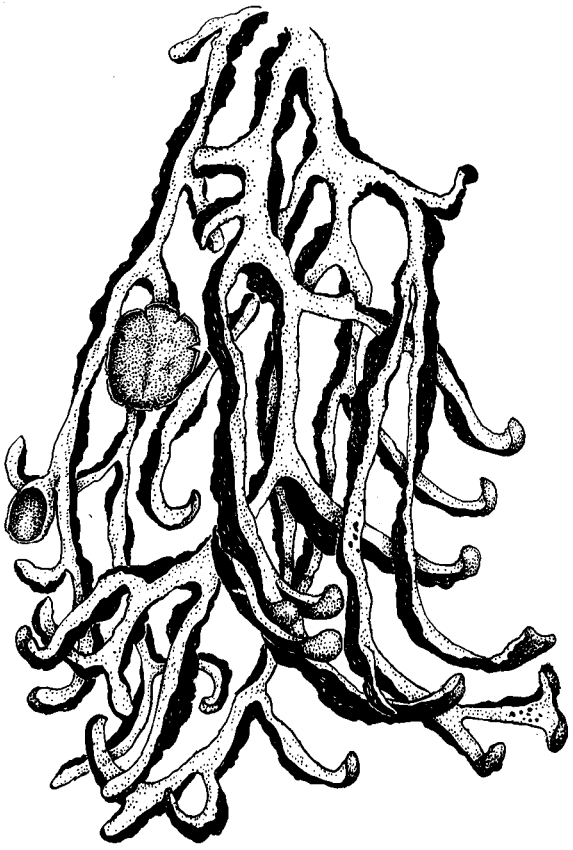

Figure 11. Drawing of *Hypogymnia duplicata.*

D. Habitat Characteristics and Species Abundance

H. duplicata occurs as an epiphyte on mountain hemlock (*Tsuga mertensiana*), western hemlock (*T. heterophylla*), Pacific silver fir (*Abies amabilis*), subalpine fir (*A. lasiocarpa*) and Douglas-fir (*Pseudotsuga menziesii*) in old-growth forests of the western Cascades, Olympics, and Oregon Coast Range between 330-1660 m (1100-5450 ft) elevation. In the western North Cascades, *H. duplicata* is generally found in high precipitation areas in old-growth mountain hemlock/Pacific silver fir forests in the moist Alaska Huckleberry (*Vaccinium alaskaense*) plant associations, and most commonly as an epiphyte on mountain hemlock trees. This species has been recorded as locally abundant at a few sites in northwestern Washington. Two known sites are in lower elevation old-growth western hemlock forests in the high precipitation areas of the South Fork Stillaguamish watershed. High precipitation areas in northwestern Washington are characterized by more than 280 cm (110 in) of precipitation at sea level (Potential Natural Vegetation Model, Henderson 1998). It appears that this species may be more responsive to macroclimate than microclimate. There are areas where it has been found growing in exposed areas, but where the humidity was high.

General habitat information is recorded for Oregon populations. Habitat descriptions include mid-elevation moist western hemlock stands, old-growth Douglas-fir (*Pseudotsuga menziesii*), mature western hemlock/Douglas-fir forest, moist Pacific silver fir or noble fir (*Abies procera*) forests, Sitka spruce (*Picea sitchensis*), riparian forest and late-successional forests along ridgetops in the Oregon Coast Range. Very small populations are reported from known sites in the Oregon Coast Range (Mikulin and Dijiacomo pers. comm.).

Occasionally, atypical habitat conditions are documented for this species. These habitats are described as forests on a lava flow and a lahar in northwestern Washington, on a snag in a bog in the Oregon Coast Range, and on moss-covered basalt outcrops on a windswept ridge of Saddle Mountain in Oregon.

II. CURRENT SPECIES SITUATION

A. Why Species is Listed Under the Survey and Manage Standard and Guideline

H. duplicata was considered at risk under the Northwest Forest Plan because of its presumed rarity and limited distribution in the range of the northern spotted owl (USDA and USDI 1994a, 1994b). At the time of the lichen viability panel, it was known from four sites in the region (USDA and USDI 1994a, 1994b). This species is endemic to the Pacific Northwest and reaches its southern limit in Oregon. The concern for species persistence under the Northwest Forest Plan varies from moderate in northwestern Washington, to high in southern Washington and Oregon where populations are fewer and more isolated, based on current information. Information acquired since the original viability rating (USDA and USDI 1994a) and additional species analysis for the FSEIS (USDA and USDI 1994b) provide more locations for this species than previously known, and suggests it may not be as rare in northwestern Washington as was previously thought. However, *H. duplicata* still displays a narrow ecological amplitude and a limited distribution.

H. duplicata was listed under the Survey and Manage Standard and Guideline to manage known sites, to locate additional populations on federal lands, and to identify high priority sites for management (USDA and USDI 1994c). Concern was expressed for lichens in general because of their sensitivity to air pollution (USDA and USDI 1994a, 1994b), but the pollution sensitivity of *H. duplicata* is unknown.

B. Major Habitat and Viability Considerations

The major viability consideration for *H. duplicata* is loss of populations resulting from management activities that affect the populations or their habitat. The species' distribution along the western edge of the North Cascades may make it vulnerable to air pollution effects, if this species is determined to be sensitive to air pollutants. A warming climate may stress populations at the limits of this species' range, which could result in a decline in vigor and a more restricted distribution for *H. duplicata*.

C. Threats to the Species

Threats to *H. duplicata* are those actions that disrupt stand conditions necessary for its survival, which include treatments that may affect populations such as removing colonized substrate, stand treatments that change the microclimate or forest structure, and possibly a significant deterioration in air quality.

D. Distribution Relative to Land Allocations

The distribution of known sites of *H. duplicata* relative to land allocations needs to be determined. Each administrative unit should evaluate the land allocations for known sites on lands in its jurisdiction, and share this information at the regional level.

III. MANAGEMENT GOAL AND OBJECTIVES

A. Management Goal for the Species

The goal for managing *H. duplicata* is to assist in maintaining species viability.

B. Objectives

Manage known sites on federal lands by maintaining the habitat, forest structure, substrate, and microclimate associated with *H. duplicata*.

IV. HABITAT MANAGEMENT

A. Lessons From History

Lichen species with specific ecological requirements may experience population declines in response to land management activities that affect habitat or decrease potential or occupied habitats. Loss of lichen species richness has been documented in areas of Europe in response to land management practices (Rose 1988, Olsen and Gauslaa 1991, Esseen *et al*. 1992). The close association of *H. duplicata* with old-growth forests in the Pacific Northwest indicates specific ecological requirements, and may reflect the inability of this species to become established or maintain populations in younger forests.

Many lichen species are known to be sensitive to air pollution, and lichen population declines attributed to air pollution have been documented in Europe and North America (Rao and LeBlanc 1967, Skye and Hallberg 1969, Hawksworth 1971, Ferry et al. 1973, Hawksworth and Rose 1976, Case 1980, Sigal and Nash 1983, Gilbert 1992). However, the pollution sensitivity of *H. duplicata* is unknown.

B. Identifying Habitat Areas for Management

All known sites of *H. duplicata* on federal lands administered by the Forest Service and BLM in the range of the northern spotted owl are identified as habitat areas where these management recommendations apply. A habitat area for management is defined as suitable habitat occupied by or adjacent to a known population.

C. Managing In Habitat Areas

- Determine the extent of the local population and habitat area with a field visit.
- Habitat areas should be managed to include an area large enough to maintain the ecological conditions associated with *H. duplicata*, including forest structure and microclimatic conditions.
- Maintain occupied substrate and provide for a distribution of appropriate substrate in habitat areas.
- Restrict thinning and other stand treatments that could alter the stand microclimate.
- Prevent fire in habitat areas, with emphasis on fire suppression.
- Restrict collecting specimens where this species is rare or of limited abundance.

Ecological and habitat conditions where populations of *H. duplicata* occur will vary across the range of the species. In general, known habitat areas are characterized as cool, moist forests with high humidity and old-growth to climax forest structure. Less common or atypical habitat conditions have been documented for this species. At all locations, current habitat conditions should be maintained. The size of the area necessary to maintain populations should be determined by a field visit.

Most known sites in the range of the northern spotted owl are on the Mt. Baker-Snoqualmie NF. The current management direction for this Forest under the Northwest Forest Plan allocates a majority of the land base to reserve status, and therefore very little of the landscape is available for management treatments that may affect this species.

Although *H. duplicata* is restricted in its ecological distribution, it may be locally common in certain areas on the Mt. Baker-Snoqualmie NF. In these areas, if a population of *H. duplicata* is in a project area, evaluate several factors to determine the importance of the population in relation to other known sites, and the contribution of that population to the species' persistence. Consider the landscape and ecological context of the population— e.g., factors such as the location of the population relative to other known populations, its relative isolation, the ecological conditions of the site and how they compare to other known sites (typical or atypical), the areal extent of the population and the abundance of the lichen in the local population, and the availability of suitable habitat in the area. Each local population should be maintained intact, however, it may be acceptable to impact a small percentage of known individuals at a particular site if it has only minimal impact to the integrity of the local population. Special consideration

should be given to maintaining populations near the edge of the geographical range of *H. duplicata*, and in watersheds where it is rare or of limited distribution.

D. Other Management Issues and Considerations

- In the range of *H. duplicata* where old forests are limited in extent, target the older stands in watersheds to meet the Standard and Guideline for 15% retention of old-growth in watersheds where little remains. Maintaining the older age classes across the landscape is important for *H. duplicata* as this lichen typically does not occur in younger-aged late-successional forests.
- Providing a well-distributed network of older forests in the range of *H. duplicata* will provide stands to replace those lost to fire, blowdown, or other natural disturbance events.

V. RESEARCH, INVENTORY, AND MONITORING NEEDS

The objective of this section is to identify opportunities to acquire additional information which could contribute to more effective species management. The content of this section has not been prioritized or reviewed as to how important the particular items are for species management. The inventory, research, and monitoring identified below are not required. These recommendations should be addressed by a regional coordinating staff.

A. Data Gaps and Information Needs

- Revisit known sites to verify the status of known populations of *H. duplicata*, determine their extent and abundance, and characterize ecological conditions.
- Determine the distribution of *H. duplicata* in areas identified as potential suitable habitat. Assign priority to Strategy 3 surveys in areas where management treatments or projects are scheduled or proposed.

B. Research Questions

- What habitat characteristics and ecological conditions are necessary for establishment of *H. duplicata* propagules and survival of established thalli?
- Is *H. duplicata* sensitive to air pollution?
- At what point in stand development (stand age, successional stage) does *H. duplicata* enter the stand?
- What are the reproductive and dispersal mechanisms, and dispersal distances for *H. duplicata*?
- What are the rates of growth and reproduction for *H. duplicata*?
- What limits dispersal and establishment of propagules and colonization in suitable habitat?
- What is the genetic diversity of this species within its local populations and across the region?

C. Monitoring Needs and Recommendations

- If management activities are planned near known sites, monitor the population to determine response to treatment and effects on the local population.
- Consider establishment of air quality monitoring plots near selected known populations.

Hypogymnia oceanica

SUMMARY

Species: *Hypogymnia oceanica* Goward
Taxonomic Group: Lichens (Rare Oceanic-Influenced)
ROD Components: 1, 3

Other Management Status:
The Nature Conservancy Oregon State Rank 2 (imperiled because of rarity or because other factors demonstrably make it very vulnerable to extinction (extirpation) typically with 6-20 occurrences). Nature Conservancy Global Rank 3 (rare, uncommon or threatened, but not immediately imperiled, typically with 21-100 occurrences) (Oregon Natural Heritage Program 1998). BLM Sensitive (Oregon BLM Sensitive List 1995).

Range: *Hypogymnia oceanica* is known from about 50 sites in the range of the Northwest Forest Plan. Eight sites are in Washington, two are coastal and six are inland on the Gifford Pinchot NF. In Oregon, almost most half of the known sites were recently found inland on the Mt. Hood NF; 10 more are from other inland Oregon sites, and 13 are coastal sites. *H. oceanica* is a Pacific Northwest endemic, ranging from Southeast Alaska where it is common to Oregon, where it is rare and reaches the southern extent of its range in Jefferson County.

Specific Habitat: Habitat characteristics for this species are poorly understood. In the Coast Range, *H. oceanica* occupies mesic to moist sites, and grows in mesic western hemlock and Douglas-fir forests in the western Cascades. Sites on Mt. Hood NF sites are open-grown mature Pacific silver fir, where small individuals are closely appressed above the snow line on tree boles.

Threats: The major threat to *H. oceanica* is loss of sites resulting from activities that harm the local populations or their habitat, including altering microclimate and removing colonized substrate.

Management Recommendations:
- Manage known sites on federal lands by maintaining habitat, forest structure, occupied and potential suitable substrate, and microclimatic conditions required by *H. oceanica*.
- Determine the extent of local sites and habitat area with a site visit.

Information Needs:
- Determine the distribution and habitat conditions for *H. oceanica* in the range of the Northwest Forest Plan.
- Evaluate species distribution and abundance relative to land allocations to determine if the current reserve land allocations are sufficient to maintain persistence of *H. oceanica.*

I. NATURAL HISTORY

A. Taxonomy and Nomenclature

H. oceanica Goward was described in 1988.

B. Species Description

1. Morphology and Chemistry

H. oceanica is a small- to medium-sized, whitish to greenish-gray, foliose lichen with long, narrow, puffy, hollow lobes (**Figure 12**). The lower surface is black, wrinkled, and bare. Soredia are present on upper lobe surfaces at the tips and towards the thallus center. Lobe tips are brownish and often perforated.

Technical Description: Thallus foliose, rather closely appressed throughout, small to medium (5-8 cm in diameter). Lobes hollow, averaging 1.5-2.0 (3.0) mm broad, somewhat elongate, irregularly inflated, generally bearing sparse, basally constricted marginal lobules, these eventually developing into more or less perpendicular secondary lobes. Upper surface pale mineral gray to nearly white, shiny, plane to convex, smooth to becoming, in part, weakly rugose as seen from above, usually distinctly bordered by the expanded shiny, black, wrinkled lower surface. Soredia subgranular, whitish, subapical to more often distinctly laminal, arising from the dissolution of the upper cortex, either confined to small circular soralia or becoming diffuse over the entire upper surface. Medulla thin, cottony, at first white but soon darkening. Apothecia and conidiomata unknown. Cortex K+ yellow; medulla K-, C-, KC+ red, PD+ red, I- (Goward 1988).

2. Reproductive Biology

Although the species description states that sexual reproductive structures are unknown (Goward 1988), another source (McCune and Geiser 1997) state that apothecia occur uncommonly. This species also reproduces asexually by production of soredia, which could be dispersed by wind, birds or insects or other vectors. Its patchy distribution at sites where it occurs suggests that it may have dispersal or establishment limitations.

3. Ecological Roles

Very little is known about the ecology of *H. oceanica*. The ecological requirements and roles of inland populations, including those around Mt. Hood, may be very different than those of coastal populations.

C. Range and Known Sites

H. oceanica is currently known from about 50 sites in the range of the Northwest Forest Plan. Only nine sites are from Washington, two near the ocean, one from Sulfur Creek Lava Flow (Mt. Baker Snoqualmie NF) and six on the Gifford Pinchot NF.

In Oregon, almost half of these sites are inland on the Mt. Hood NF; 10 more are from other inland sites, and 13 are from coastal sites. No sites south of Jefferson County are known. Until about 1995, this species was believed to be a strictly coastal Pacific Northwest endemic, ranging from Southeast Alaska where it is common (Geiser et al. 1998) into Oregon, where it is rare. We now know that it has a strong inland showing in the western Cascades of Oregon, and occurs in the western Cascades of Washington as well. Our knowledge of the range of *H. oceanica* is incomplete.

D. Habitat Characteristics and Species Abundance

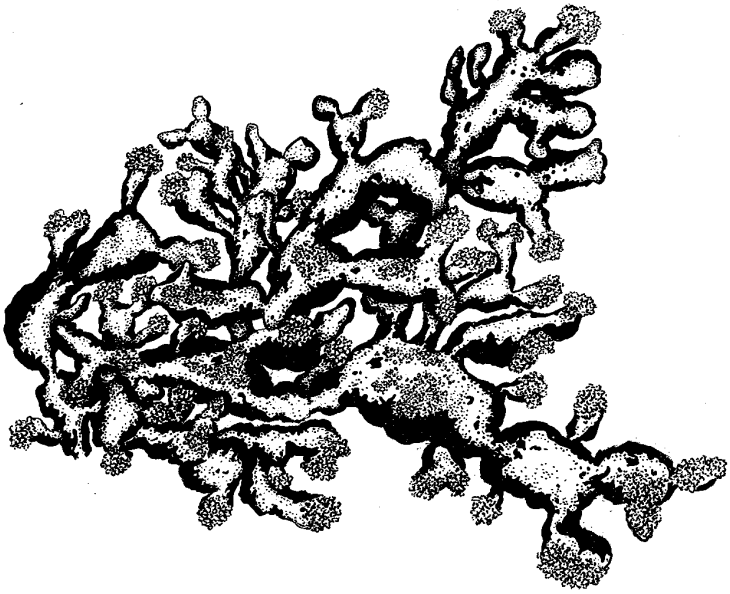

Figure 12. Drawing of *Hypogymnia oceanica.*

H. oceanica is uncommon in the range of the northern spotted, known from about 50 sites in coastal areas and in the western Cascades of Washington and Oregon. Habitat characteristics for *H. oceanica* in the range of the Northwest Forest Plan are poorly known. It occurs in moist Sitka spruce (*Picea sitchensis*) and shore pine (*Pinus contorta*) forests along the immediate coast and in Douglas-fir (*Pseudotsuga menziesii*) and western hemlock (*Tsuga heterophylla*) forests in the Coast Range and Cascade Mountains (McCune and Geiser 1997). The Mt. Hood sites are typically rather open-grown mature Pacific silver fir (*Abies amabilis*) forests, where small individuals are often closely appressed to tree boles above the snow line. It appears to have a sparse and patchy distribution in stands where it does occur. *H. oceanica* occurs in late-successional and old-growth stands.

On the Mt. Baker-Snoqualmie NF, *H. oceanica* occurs at the Sulphur Creek Lava Flow. The mid-elevation (550-660 m; 1640-2170 ft) lava flow supports scattered live, dead, and dying subalpine fir infested with balsam woolly aphid. The stand has a dense shrub component of vine maple (*Acer circinatum*) and huckleberry (*Vaccinium* spp). The lava flow is unusual in that it supports relatively low-elevation stands of subalpine fir (*Abies lasiocarpa*) with an epiphytic lichen flora that appears to be more similar to that of Douglas-fir stands than subalpine fir in its typical, higher elevation sites (Rhoades 1981).

In British Columbia, it is infrequent over conifers in open to shady coastal low elevation forests and rare in humid intermontane forests (Goward et al. 1994). In Southeast Alaska, *H. oceanica* is coastal and common on the trunks and branches of open-grown shore pine (*Pinus contorta*) in *Sphagnum* bogs, on Sitka spruce (*Picea sitchensis*) and western hemlock (*Tsuga heterophylla*) in forested stands, and on apple (*Malus*) and alder (*Alnus*) along beach fringes (Geiser et al. 1998).

II. CURRENT SPECIES SITUATION

A. Why Species Is Listed Under Survey and Manage Standard and Guideline

H. oceanica was considered at risk under the Northwest Forest Plan because of its rarity and limited distribution in the range of the northern spotted owl (USDA and USDI 1994a). At the time of the FEMAT viability ratings there was only one known population in the range of the northern spotted owl (USDA and USDI 1994a and 1994b).

B. Major Habitat and Viability Considerations

The major viability consideration for *H. oceanica* is loss of populations resulting from management activities that harm the populations or impact their habitat. It has recently been found in several timber units on the Mt. Hood NF.

C. Threats to the Species

Threats to *H. oceanica* are those activities that alter existing stand and microsite conditions or affect the occupied substrate. Because its distribution and habitat requirements in the range of the Northwest Forest Plan are poorly known, it is difficult to assess threats. Fire, including prescribed burns, could threaten populations of this species.

D. Distribution Relative to Land Allocations

The distribution of known sites of *H. oceanica* relative to land allocations needs to be determined. It is suggested that each administrative unit evaluate the land allocations for known sites on lands in its jurisdiction and share this information at the regional level.

III. MANAGEMENT GOALS AND OBJECTIVES

A. Management Goal for the Species

The goal for managing *H. oceanica* is to assist in maintaining species viability.

B. Objectives

Manage known sites on federal lands by maintaining habitat, forest structure, occupied and potential suitable substrate, and micro-climate conditions associated with *H. oceanica*.

IV. HABITAT MANAGEMENT

A. Lessons from History

No specific lessons from history about *H. oceanica* have been identified.

B. Identifying Habitat Areas for Management

Known sites of *H. oceanica* on federal lands administered by Forest Service and BLM in the range of the Northwest Forest Plan are identified as habitat areas where these management recommendations should be implemented, especially until the distribution and habitat requirements of this species are better understood. A habitat area for management is defined as suitable habitat occupied by or adjacent to a known population.

C. Managing In Habitat Areas

- Determine the extent of local population and habitat area with a site visit.
- Manage habitat area by maintaining forest structure, occupied and potentially suitable substrate, and microclimatic conditions required by *H. oceanica*.
- Avoid prescribed burns in habitat areas where this species occurs.

D. Other Management Issues and Considerations

Since the FEMAT report (USDA and USDI 1994a), an additional 50 sites have been discovered, and this species may turn out to be more common than originally thought.

V. RESEARCH, INVENTORY, AND MONITORING NEEDS

A. Data Gaps and Information Needs

The objective of this section is to identify opportunities to acquire additional information that could contribute to more effective species management. The content of this section has not been prioritized or reviewed as to how important the particular items are for species management. The inventory, research, and monitoring identified below are not required. These recommendations should be addressed by a regional coordinating staff.

- Determine the distribution of *H. oceanica* in the range of the Northwest Forest Plan.
- Characterize the ecological conditions of *H. oceanica* in the range of the Northwest Forest Plan.
- Evaluate species distribution and abundance relative to land allocations to determine if the current reserve land allocations are sufficient to maintain persistence of *H. oceanica.*
- Survey potential suitable habitat at Gwynn Creek, Eel Creek Recreation Area and Sand Lake, Siuslaw NF; and BLM parcels adjacent to Cape Lookout, and other BLM coastal parcels for *H. oceanica*.
- Share information with State and private sectors to further activities directed at the conservation of *H. oceanica.*
- Does the species require different management in different parts of its range (e.g., inland versus coastal populations)?

B. Research Questions

- Are Mt. Hood and other inland populations genetically different from coastal populations?
- What are the rates of reproduction, dispersal and growth for *H. oceanica*?

C. Monitoring Needs and Recommendations

No monitoring needs are recommended at this time.

Hypogymnia oceanica

Kaernefeltia californica

SUMMARY

Species: *Kaernefeltia californica* (Tuck.) Thell & Goward [formerly *Cetraria californica* Tuck.]
Taxonomic Group: Lichens (Oceanic-Influenced)
ROD Components: 1, 3

Other Management Status: None

Range: *Kaernefeltia californica* is a hypermaritime lichen endemic to the west coast of North America, occurring in a narrow coastal band from southeastern Alaska south to central California. In the range of the Northwest Forest Plan, it is known from 42 sites: four in Washington, 27 in Oregon and 11 in California.

Specific Habitat: *K. californica* appears to be strictly coastal in most of its range. It is found in a narrow coastal band in conifer thickets, especially in the extensive Oregon dune sheet systems. *Kaernefeltiafeltia californica* grows on the bark, twigs, or cones of open grown conifers, especially bishop and shore pine, and on wooden fence posts and other wooden structures. Although it is found mostly at sea level or very low elevations, it has been reported from 1524 m (5000 ft) on the Hurricane Ridge Trail, Olympic National Park, and 40 miles inland near Selma, Oregon. These populations are probably *K. merrillii*, but need to be confirmed.

Threats: The major threat to *K. californica* is loss of populations resulting from activities that impact the population or its habitat, including altering the microclimate and removing colonized substrate. These activities would most likely be recreation-related, such as building trails and shelters, collecting firewood, and bicycle, off-road vehicle and foot traffic. The species is vulnerable to loss of habitat resulting from increasing building and clearing along the coast.

Management Recommendations:

- Manage known sites by maintaining ecological conditions associated with *K. californica*, including forest structure, substrate, and micro-climatic conditions.
- Restrict building, burning, collecting specimens, collecting firewood, operating off-road vehicles and bicycles, and other recreational activities or development that could affect colonized substrates and harm known populations.

Information Needs:

- Verify the status of known populations and characterize the habitat.
- Determine if this species meets the criteria for close association with late-successional or old-growth forests.
- Check collections of *K. californica* and *K. merrillii* in the range of the Northwest Forest Plan to confirm identification of these often confused species.
- Locate additional populations of *K. californica* in potentially suitable habitat on federal land along the immediate coast in the range of the Northwest Forest Plan.

I. NATURAL HISTORY

A. Taxonomy and Nomenclature

K. californica (Tuck.) Thell & Goward (Thell and Goward 1996) was originally described as *Cetraria californica* Tuck. and was referred to by this name in the Forest Ecosystem Management Assessment Team report (USDA and USDI 1994a) and subsequent documents (USDA and USDI 1994b, 1994c).

Synonyms:

Cetraria californica
Tuckermannopsis californica
Cornicularia californica
Coelocaulon californicum
C. cetrariza
Alectoria californica
A. cetrariza

B. Species Description

1. Morphology and Chemistry

This small (generally <2 (3) cm diameter) tufted, fruticose lichen is roundish to irregular in cross-section and varies from pale olive brown to olive black. Soredia and isidia are lacking but it has some short pointed branches, that may appear isidia-like (**Figure 13**). Apothecia are fairly common. This species is frequently confused with *K. merrillii* (formerly *Cetraria merrillii*) and *Nodobryoria abbreviata* (formerly *B. abbreviata*), but is easily distinguished from these species in both habitat and form because neither of them are reported from oceanside forests (McCune and Geiser 1997; Thell and Goward 1996). *K. californica* is typically richly fertile, usually pale brownish, and has rather knobby branches often lightly covered with whitish pruina, while *K. merrillii* usually is sparsely fertile, has flatter, darker (greenish black) moderately smooth lobes lacking any trace of pruina (Thell and Goward 1996). Also, a sectioned epithecium of *K. californica* stains K+ purple and *K. merrillii* is K- (McCune, pers. comm.). *Nodobryoria abbreviata* is reddish brown and usually has terminal apothecia that are often marginally ciliate (McCune and Geiser 1997).

Technical Description: Thallus fruticose, up to 1.5 cm high, tufted or decumbent, gray or grayish- brown or pale to dark olive-brown, always paler in central parts; lobes rounded-angular to flattened in transverse section, to 1.0 (1.5) mm wide, frequently ridged and knobby, in part covered in whitish pruina; pseudocyphellae occasional, more or less distinct, immersed; cilia occasionally present, barely separate from smaller side lobes; isidia absent; rhizines absent; cortex usually 2-layered. Apothecia frequent, terminal, subterminal, or lateral, disc to 3 mm in diameter, dark brown or blackish, at first concave, later becoming convex. Photobiont is a green alga (Thell and Goward 1996).

2. Reproductive Biology

K. californica reproduces sexually by producing fungal spores in apothecia. True vegetative reproductive structures (i.e., soredia and isidia) are unknown, but given the brittle nature of the thallus and its tiny branches, this species may also reproduce through fragmentation.

3. Ecological Roles

This uncommon hypermaritime species is apparently confined to western North America at low elevations along the Pacific Ocean (Thell and Goward 1996), suggesting a narrow ecological amplitude. Specific ecological roles and interactions are unknown, although it occurs with other rare Survey and Manage lichen species.

C. Range and Known Sites

K. californica is an uncommon, hypermaritime lichen endemic to the west coast of North America, occurring in a narrow coastal band from southeastern Alaska (Geiser et al. 1998) south to central California (Thell and Goward 1996). In the range of the Northwest Forest Plan, it is known from 42 sites: four in Washington, 27 in Oregon, and 11 in California. In Washington, it is known from Clallam and Grays Harbor Counties; in Oregon, from Tillamook, Lane, Linn, Lincoln, Douglas, Josephine, Curry, and Coos Counties; and in California from Humboldt and Mendocino Counties.

Figure 13. Drawing of *Kaernefeltia californica.*

In Washington, it is found in Olympic National Park, Westport Lighthouse State Park, and land near Grays Harbor of unknown ownership. In Oregon, it occurs near Lincoln City; near Cape Lookout and Cape Sebastian State Parks; in or near South Beach State Park; in the BLM Heceta Dunes Area of Critical Environmental Concern (ACEC), North Fork Hunters Creek ACEC, and New River ACEC; on the Siuslaw NF at Heceta Beach, Sutton Creek, Bluebird Campground, near North Bend, at Horsefall Dunes, Clear Lake; and at several sites in the Oregon Dunes National Recreation Area. Two inland collections near Cave Junction and Selma, Oregon, should be verified, as they may be *K. merrillii*. In California, *K. californica* occurs at Patrick's Point State Park, Lanphere Dunes Unit (Humboldt Bay National Wildlife Refuge, USFWS), on the Samoa Peninsula, and at several sites in the pygmy forest habitat near Mendocino. Only about 10 of these sites are on federally managed lands, mainly on the Siuslaw NF and Heceta Dunes BLM land. Most of these sites need to have land ownership determined or verified.

D Habitat Characteristics and Species Abundance

K. californica occurs in the narrow coastal band in conifer thickets, especially in the extensive Oregon dune sheet systems. It appears to be strictly coastal over most of its range (Thell and Goward 1996), mostly at sea level or very low elevations. *K. californica* tends to grow on bark, twigs, or cones, of open grown conifers especially bishop pine (*Pinus muricata*) and shore pine (*Pinus contorta*), and on wooden fence posts and other structures. Although it has been reported from 1524 m (5000 ft) on the Hurricane Ridge Trail, Olympic National Park, and at 365 m (1200 ft) about 40 miles inland on the Siskiyou NF near Selma, vouchers from these two inland sites should be reexamined to confirm they are not *K. merrillii*. *K. californica* is a Pacific Northwest endemic (Thell and Goward 1996). It can be locally abundant at some sites, although it is considered rare throughout its range (Thell and Goward 1996).

II. CURRENT SPECIES SITUATION

A. Why Species Is Listed Under Survey and Manage Standard and Guideline

K. californica was considered at risk under the Northwest Forest Plan because of its rarity and limited distribution within the range of the northern spotted owl. At the time of the FEMAT viability analysis, this species was known from 17 sites within the range of the northern spotted owl (USDA and USDI 1994a and b).

B. Major Habitat and Viability Considerations

The major viability consideration for *K. californica* is loss of populations resulting from management activities which impact the habitat or the populations.

C. Threats to the Species

Threats to *K. californica* are those actions that harm the populations or impact their habitat, including altering the microclimate and removing colonized substrate, which could result in the loss of individuals and populations. These would most likely be activities related to recreation such as building trails and shelters, collecting firewood, and off-trail bicycle, off-road vehicle and foot traffic. It is vulnerable to loss of habitat due to increasing construction and clearing along the coast.

D. Distribution Relative to Land Allocations

Many of the sites of *K. californica* need to have land ownership and land allocations verified. Several populations are in BLM Areas of Critical Environmental Concern and in the Oregon Dunes National Recreation Area, as well as Washington, Oregon, and California State Parks.

III. MANAGEMENT GOAL AND OBJECTIVES

A. Management Goal for the Species

The goal for the management of *K. californica* is to assist in maintaining species viability.

B. Objectives

Manage known sites on federal lands by maintaining habitat, forest structure, occupied and potentially suitable substrate, and microclimatic conditions associated with *K. californica*, and by allowing existing habitat conditions to persist and evolve naturally.

IV. HABITAT MANAGEMENT

A. Lessons From History

No specific lessons from history about *K. californica* have been identified.

B. Identifying Habitat Areas for Management

All known sites of *K. californica* on federal land administered by the Forest Service or BLM in the range of the Northwest Forest Plan are identified as areas where these management recommendations should be implemented. A habitat area for management is defined as suitable habitat occupied by or adjacent to a known population.

C. Managing in Habitat Areas

The objective of management in habitat areas is to maintain suitable habitat for *K. californica.*

- Manage known sites by maintaining ecological conditions associated with *K. californica*, including forest structure, substrate, and micro-climatic conditions.
- Collecting firewood should be restricted.
- Collecting of voucher specimens should be restricted unless they are found in litterfall.
- Restrict off-road vehicle and bicycle traffic in coastal ericaceous shrub habitats without trails.
- Minimize the extent of shrub and tree clearing along trails during maintenance activities.
- Develop practices to route human use away from the populations (e.g., divert trails and roads). The trampling of shrubs, removing trees or branches, introducing non-native species by seed dispersal or planting, compacting of tree or shrub roots which support the species, are all examples of potential recreational impacts.

D. Other Management Issues and Considerations

Determine if *K. californica* meets the criteria for inclusion on the Survey and Manage species list. For a species to be appropriately listed as a Survey and Manage species, it must first meet the criteria established for designation as a species closely associated with late-successional or old-growth forests (USDA and USDI 1994a [Table IV-6] and 1994b).

- Share information with State and private sectors to further activities directed at conservation of *K. californica*.
- Consider opportunities for managing known sites during Forest Plan or Resource Management Plan revisions, such as designating Botanical Special Interest Areas (BSIA), Areas of Critical Environmental Concern (ACEC), or other administratively withdrawn areas, or by prescribing special standards and guidelines.
- Request the Oregon and Washington State Natural Heritage Programs track and store information for *K. californica* across all land ownerships.

V. RESEARCH, INVENTORY, AND MONITORING NEEDS

The objective of this section is to identify opportunities to acquire additional information which could contribute to more effective species management. The content of this section has not been prioritized or reviewed as to how important the particular items are for species management. The inventory, research, and monitoring identified below are not required. These recommendations should be addressed by a regional coordinating staff.

A. Data Gaps and Information Needs

- Re-examine inland collections of *K. californica* in the range of the Northwest Forest Plan to confirm identifications
- Determine if *K. californica* is closely associated with late-successional or old-growth forests following the criteria established in FEMAT ([Table IV-6], USDA and USDI 1994a).
- Determine distribution of *K. californica* in areas identified as potentially suitable habitat. There are several other federally managed parcels of coastal fog zone habitat with populations of other rare oceanic lichens with similar habitat requirements. They are Gwynn Creek, Sand Lake, and Eel Creek (Siuslaw NF, Oregon Dunes National Recreation Area), BLM Heceta Dunes ACEC; a small BLM parcel near Cape Lookout State Park; and other coastal BLM parcels.
- Identify which areas provide the most optimal *K. californica* habitat, as suggested by an abundance of the species.

B. Research Questions

- What are the dispersal rates and mechanisms of *K. californica*?
- Which habitat characteristics and ecological conditions are necessary for survival of *K. californica* propagules?
- What limits dispersal and establishment of propagules and colonization of suitable *K. californica* habitat?
- Is *K. californica* sensitive to air pollution?
- Which other rare lichens occur with *K. californica*?
- Do refugial populations disperse into managed stands?

C. Monitoring Needs and Recommendations

No monitoring needs are identified at this time.

Leioderma sorediatum

SUMMARY

Species: *Leioderma sorediatum* D.J. Galloway & P.M. Jørg.
Taxonomic Group: Lichens (Rare Oceanic-Influenced)
ROD Components: 1, 3

Other Management Status: Oregon State Rank 1 (critically imperiled because of extreme rarity or because it is somehow especially vulnerable to extinction or extirpation, typically with 5 or fewer occurrences); Oregon Natural Heritage Program Rank 2 (imperiled because of rarity or because other factors demonstrably makes it very vulnerable to extinction (extirpation), typically with 6-20 occurrences. Global Rank 3 (not rare and apparently secure, but with cause for long-term concern) (Oregon Natural Heritage Program 1998). BLM Assessment Species (USDI Bureau of Land Management 1998).

Range: *Leioderma sorediatum* is known from only four localities in North America: two on federal land in Oregon (Siuslaw NF); one in Washington (private land); and one on Vancouver Island, British Columbia.

Specific Habitat: In the range of the Northwest Forest Plan, *L. sorediatum* is found in semi-open coastal thickets, most often in dune woodlands, deflation plains, and ericaceous shrub thickets. The Sutton Creek Recreation Area site is an old, open shore pine-ericaceous shrub forest with little or no Sitka spruce in the canopy; *L. sorediatum* is epiphytic over thin bryophyte mats on the stems of ericaceous shrubs. In Washington, it is found in a young riparian stand of red alder surrounded by clearcuts, and was on the bole of a 10-cm-dbh alder.

Threats: The major threat to *L. sorediatum* is loss of populations resulting from activities that harm the population or impact its habitat, including altering the microclimate and removing colonized substrate. These activities would most likely be related to recreation, such as building trails and shelters, collecting firewood, and off-trail bicycle, off-road vehicle and foot traffic. It is probably sensitive to air pollution from vehicle exhaust and burning. It is vulnerable to loss of habitat from development along the coast, and the encroachment of non-native invasive plants.

Management Recommendations:
- Manage populations at known sites by maintaining ecological conditions associated with *L. sorediatum*, including stand structure, substrate, and micro-climatic conditions.
- Restrict building, burning, collecting specimens, collecting firewood, operating off-road vehicles and bicycles, and other recreational activities or development that could affect colonized substrates and harm known populations.
- Develop practices to route human use away from known sites to minimize impact to the populations and their habitat.

Information Needs:
Determine if this species meets the criteria for being closely associated with late-successional or old-growth forests.

Leioderma sorediatum

I. NATURAL HISTORY

A. Taxonomy and Nomenclature

Leioderma sorediatum D.J. Galloway & P.M. Jørg. was described in 1987 by Galloway and Jørgensen.

B. Species Description

1. Morphology

L. sorediatum is a small, stratified, foliose lichen that lacks a lower cortex and is sorediate above (**Figure 14**). The upper surface is grayish, bearing distinctive minute appressed woolly hairs; thallus lobes are loosely attached and round. The lower surface lacks veins and has short to longish marginal or scattered rhizines. *L. sorediatum* could be confused with *E. sorediatum*, but the latter species has erect tomentum on the upper surface and has a PD+ reaction (eriodermin) (Tønsberg, pers. comm.). *L. sorediatum* is PD- and has appressed woolly hairs. *L. sorediatum* superficially resembles *Peltigera collina*; the latter has veins on the lower surface (McCune and Geiser 1997).

Technical description: Thallus foliose, lobate, orbicular to irregularly spreading 1-3(4) cm diameter, rather loosely attached. Lobes to 6 mm wide, discrete to imbricate. Margins slightly thickened, sinuous, subascendent, entire, delicately incised or crenulate, sorediate. Soralia marginal, often more or less sinuous, linear to limbiform, occasionally round, and spreading on to upper (or lower) surface; soredia coarsely granular, bluish. Upper surface more or less uniformly arachnoid-tomentose, dark blue-green when wet, pale-grayish or olivaceous-gray when dry, often with pale, pinkish-brown apothecial initials. Lower surface white, ecorticate, arachnoid, especially at the margins, pale buff towards center, rhizinate; rhizines white, buff to bluish, rarely blackened, in fascicles tufted at apex, in scattered groups or more or less densely developed. Photobiont is a cyanobacterium. Apothecia rare (Galloway and Jørgensen 1987:390).

2. Reproductive Biology

This species reproduces asexually by producing soredia that are distributed by wind, gravity, animals, or birds (McCune and Geiser 1997). Apothecia are very rare in *L. sorediatum* (Galloway and Jørgensen 1987), so sexual reproduction is probably also rare.

3. Ecological Roles

Because of its extreme rarity in North America, very little is known about the ecological roles of *L. sorediatum* in this area. It apparently is a strictly hypermaritime species, which suggests a fairly narrow ecological amplitude and an affinity for the high precipitation and humidity present in these habitats. *L. sorediatum* is a nitrogen-fixing species, providing a small amount of usable nitrogen to the ecosystems it inhabits.

C. Range and Known Sites

L. sorediatum is known from only four localities in North America: two in Oregon Sutton Creek Recreation Area (Lane County) and Eel Creek Recreation Area (Douglas County), Siuslaw NF); one in Washington on private land, Hoh River Road, Olympic Peninsula (Jefferson County) (Tønsberg, pers. comm.); and one on Vancouver Island, British Columbia (Goward et al. 1994). *L. sorediatum* is known mainly from the South Pacific, New Zealand, Australia, Sri Lanka, and mainland India; in Asia, Malaya, Japan and Hawaii; with disjunct populations on the Pacific coasts of North and South America (Galloway and Jørgensen 1987).

D. Habitat Characteristics and Species Abundance

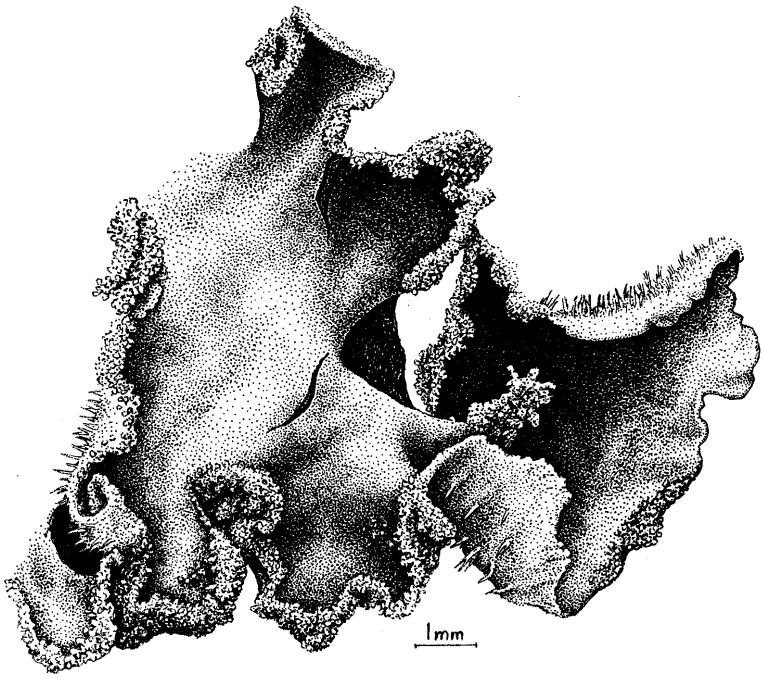

Figure 14. Drawing of *Leioderma sorediatum.*

L. sorediatum is rare in North America, with two of its four known sites on the Siuslaw NF. In Oregon, *L. sorediatum* is found in semi-open coastal thickets, and deflation plains and ericaceous shrub thickets of shore pine (*Pinus contorta*) and ericaceous shrubs on stabilized dunes and deflation plains (McCune et al. 1997). The Sutton Creek Recreation Area site is an open, old shore pine-shrub forest with little or no Sitka spruce (*Picea sitchensis*) in the canopy; *L. sorediatum* is epiphytic over thin bryophyte mats on the stems of ericaceous shrubs (*Vaccinium* spp. and *Rhododendron macrophyllum*). In Washington, it is found in a young riparian stand of red alder (*Alnus rubra*) surrounded by clearcuts, and was on the bole of a 10 cm dbh alder. This site was unusual in that the cyanolichen *L. oregana* was abundant in a young stand (Tønsberg, pers. comm.). In British Columbia, it is found over mossy conifer branches in an open hypermaritime forest (Goward et al. 1994). In the South Pacific, *L. sorediatum* grows in damp, humid habitats such as rainforests and swampy areas, where it is most commonly epiphytic on trees and shrubs in moderate light, and also occurs on pumice, clay banks, or on mossy rocks (Galloway and Jørgensen 1987). In parts of its range, it is best developed on disturbed sites, such as edges of secondary forests and road margins (McCune et al. 1997).

II. CURRENT SPECIES SITUATION

A. Why Species Is Listed Under Survey and Manage Standard and Guideline

L. sorediatum was thought to be at risk under the Northwest Forest Plan because of its rarity and limited distribution in the range of the northern spotted owl. At the time of the FEMAT viability analysis it was known from only two sites in the range of the northern spotted owl (USDA and USDI 1994a and b).

B. Major Habitat and Viability Considerations

The major viability consideration for *L. sorediatum* is loss of populations due to management activities which harm the populations or their habitat. Because of the limited extent of Oregon coastal dune habitat, the tendency of other rare oceanic lichens to be found in this habitat, the rarity of this species in North America, and land development on privately owned coastal land, all known sites on federal land are important for maintenance of the species.

C. Threats to the Species

Threats to *L. sorediatum* are those actions that harm the populations or impact their habitat, including altering the microclimate and removing colonized substrate, which could result in the loss of individuals and populations. These activities are mainly related to recreation and include building trails and shelters, collecting firewood, and off-trail bicycle, off-road vehicle, and foot traffic. As a cyanolichen, *L. sorediatum* is probably sensitive to air pollution from vehicle exhaust and fire, although its specific sensitivity is unknown. It is vulnerable to loss of habitat resulting from increased development along the

coast and the encroachment of non-native invasive plants.

III. MANAGEMENT GOAL AND OBJECTIVES

A. Management Goal for the Taxon

The goal for managing *L. sorediatum* is to assist in maintaining species viability.

B. Objectives

Manage known sites on federal lands by maintaining habitat, stand structure, occupied and potentially suitable substrate, and micro-climatic conditions required by *L. sorediatum*, and by allowing existing habitat conditions to persist and evolve naturally.

IV. HABITAT MANAGEMENT

A. Lessons From History

No specific historical lessons are available for *L. sorediatum.* As a nitrogen-fixing lichen, however, it is probably sensitive to air pollution, and in many industrialized parts of the world nitrogen-fixing lichens have disappeared due to air quality degradation (Rhoades 1988; Ryan and Rhoades 1992; Geiser et al. 1994). In many parts of the industrialized world lichen populations are declining because of habitat alteration (Seaward 1977). *L. sorediatum* habitat is at risk because of coastal development along the Oregon dunes.

B. Identifying Habitat Areas for Management

All known sites of *L. sorediatum* on federal lands in the range of the Northwest Forest Plan are identified as habitat areas where these management recommendations should be implemented. A habitat area for management is defined as suitable habitat occupied by or adjacent to a known population.

C. Managing in Habitat Areas

- Manage known sites on federal land by allowing existing habitat conditions to persist and evolve naturally.
- Collecting firewood should be restricted.
- Collecting voucher specimens for scientific purposes should be restricted, unless they are found in litterfall.
- Restrict off-trail use of vehicles, bicycles and foot traffic in areas of known populations in the coastal ericaceous shrub habitats.
- Minimize the extent of shrub and tree clearing along trails during maintenance activities.
- Develop practices to route human use away from the populations (e.g., divert trails and roads). The trampling of shrubs, removing trees or branches, introducing non-native species by seed dispersal or planting, compacting tree or shrub roots which support the species, are all examples of potential recreational impacts.

D. Other Management Issues and Considerations

Information from reported sites suggests that *L. sorediatum* may not be a species closely associated with late-successional or old-growth forests. For a species to be appropriately listed as a Survey and Manage species, it must first meet the criteria established for designating a species as closely associated with late-successional or old-growth forests (USDA and USDI 1994a [Table IV-6] and 1994b). This issue should be addressed by a regional coordinating staff.

- Share information with State and private sectors to further activities directed at the conservation of *L. sorediatum.*

- Consider opportunities for managing known sites, such as Botanical Special Interest Areas, Areas of Critical Environmental Concern, or other administratively withdrawn designation, or by prescribing special standards and guidelines during Forest Plan and Resource Management Plan revisions.
- Request the Oregon and Washington State Natural Heritage Programs track and store information for *L. sorediatum* across all land ownerships.
- Continue to work with state and federal air regulatory agencies to control off-site emission sources that adversely impact on lichens and bryophytes.

V. RESEARCH, INVENTORY, AND MONITORING NEEDS

The objective of this section is to identify opportunities to acquire additional information which could contribute to more effective species management. The content of this section has not been prioritized or reviewed as to how important the particular items are for species management. The inventory, research, and monitoring identified below are not required. These recommendations should be addressed by a regional coordinating staff.

A. Data Gaps and Information Needs

- Revisit known sites to verify the status of known populations, determine the extent of the populations and abundance, and to characterize ecological conditions.
- Determine if *L. sorediatum* meets the criteria for being closely associated with late-successional or old-growth forests.
- Determine the distribution of *L. sorediatum* in areas identified as potentially suitable habitat. Potentially suitable habitat is identified as coastal deflation dune systems with scattered old Sitka spruce, shore pine forests and ericaceous shrub thickets, and coastally influenced riparian alder stands. Areas with potentially suitable habitat include Gwynn Creek Recreation Area and Sand Lake, Siuslaw NF; BLM Heceta Dunes ACEC; and other coastal BLM parcels.
- Share information with other land management agencies regarding potentially suitable habitat in areas such as Cape Lookout, Cape Arago, and Cape Blanco State Parks.

B. Research Questions

- What are the dispersal rates and mechanisms of *L. sorediatum*?
- Which habitat characteristics and ecological conditions are necessary for survival of *L. sorediatum* propagules?
- What limits dispersal and establishment of propagules and colonization of suitable *L. sorediatum* habitat?
- Is *L. sorediatum* sensitive to air pollution?
- Which suites of other rare lichens occur with *L. sorediatum*?
- How do populations of *L. sorediatum* respond to successional changes and associated changes in microclimate?

C. Monitoring Needs and Recommendations

Monitor the effects of recreational activities on populations of *L. sorediatum* in habitat areas.

Leioderma sorediatum

Leptogium brebissonii

SUMMARY

Species: *Leptogium brebissonii* Mont.
Taxonomic Group: Lichens (Rare Oceanic-Influenced)
ROD Components: 1, 3

Other Management Status: None

Range: In the range of the Northwest Forest Plan, *Leptogium brebissonii* is known from eight sites in Oregon and one in Washington. The Washington site is on the Olympic Peninsula north of Queets. Six of the eight documented sites in Oregon are on federal lands. It occurs on Eugene District BLM in Heceta Dunes Area of Critical Environmental Concern. Five sites are on the Siuslaw NF: Eel Creek Campground, Oregon Dunes National Recreation Area; Sutton Creek Campground, Mapleton Ranger District; a ridge crest above Cedar Creek, Hebo Ranger District; and two sites in the Cascade Head Experimental Forest. Small populations have been found at Carl Washburne Memorial State Park, and the summit of Neahkahnie Mountain.

Specific Habitat: *L. brebissonii* is a strictly coastal species occurring on trees and woody shrubs from sea level to 600 m (2000 ft) elevation, within 16 km (10 mi) of the Pacific Coast. Known habitat conditions for *L. brebissonii* are coniferous and deciduous trees and shrubs in semi-exposed sites such as tree pockets on stabilized dunes, trees on the edge of dune forests, dune woodlands, wetland shrub mosaics, deciduous trees in riparian zones, and open forested stands on ridgetops. Known substrates in the range of the Northwest Forest Plan are Sitka spruce, red alder, rhododendron, evergreen huckleberry, and Hooker's willow.

Threats: The main threats are activities that directly harm the populations, their habitat, or the habitat area surrounding populations. Examples of threats include: burning (in some places); harvesting trees; constructing roads, trails or buildings; recreational activities; grazing; invasive exotic plants; changes in local hydrology; and air pollution.

Management Recommendations:
- Manage known sites to maintain populations and their habitat area.
- Develop practices to route human use away from known sites.
- Manage fire in habitat areas, with emphasis on prevention near occupied substrates.
- Restrict removal of trees, shrubs, or other vegetation from the habitat area, except when removal will not harm habitat integrity.
- Consider opportunities for managing known sites during Forest Plan and Resource Management Plan revisions, such as administratively withdrawn designations, or by prescribing special standards and guidelines.

Information Needs:
- Visit known sites to determine the extent of local populations and improve habitat descriptions.
- Determine if this species is closely associated with late-successional or old-growth forests.
- Determine if additional populations exist in areas identified as potential suitable habitat.

I. NATURAL HISTORY

A. Taxonomy and Nomenclature

L. brebissonii Mont. was described in 1840. It is a lichenized fungus in the family Collemataceae, order Lecanorales, class Ascomycetes (Tehler 1996). Sierk (1964) included some material of *L. brebissonii* in *L. platynum* (Tuck.) Herre, but the latter species grows on soil and rock and does not occur in Washington or Oregon.

B. Species Description

1. Morphology

L. brebissonii (**Figure 15**) belongs to a group of cyanobacteria-containing lichens known as gelatinous lichens. The cyanobacterial photobiont, *Nostoc*, is scattered throughout the heavily gelatinized thallus rather than in a distinct layer close to the upper surface (Sierk 1964). The medullary area is dark because little or no internal differentiation is present. When wet, *L. brebissonii* can easily be identified by the dark, swollen thallus and the indistinct, ridged lobes with marginal and laminal isidia. When dry, the lichen shrinks to an irregular, tufted, markedly ridged or wrinkled shape. The upper surface is dark green-black when wet, becoming gray-black when dry. The lower surface is similar but paler. Both surfaces lack tomentum. The lobes are partly fenestrate (having small holes). The isidia are fine granular to cylindrical and often arranged in lines along the ridges and lobe margins (Purvis et al. 1992, Goward et al. 1994b). Apothecia have not been observed in North American material (McCune et al. 1997b). This species is anomalous among the species of *Leptogium* found in the coastal Pacific Northwest in having a very thick, gelatinous thallus more reminiscent of *Collema* than of *Leptogium* (Goward et al. 1994a).

2. Reproductive Biology

Sexual reproductive structures are unknown for North American material. Instead, *L. brebissonii* reproduces by the production and dispersal of isidia. Isidia are thalloid protrusions less than 1 mm in length, that break off at the base and have the potential to be dispersed long distances by wind or animals. Birds in particular can be important vectors, dispersing lichen propagules along the coastal migratory routes (McCune et al. 1997b).

3. Ecological Roles

Because the photobiont of *L. brebissonii* is a cyanobacterium, this lichen is grouped functionally with other epiphytic nitrogen-fixing lichens. Containing up to 4% nitrogen dry weight, this group provides especially nutritious forage. Cyanolichens can also make significant contributions of fixed nitrogen to forest soils through leaching and decomposition of the thalli.

C. Range and Known Sites

L. brebissonii has a broad global distribution; it is known from the western British Islands, western Ireland, western Europe, Macronesia, East Africa, and New Zealand (Purvis et al. 1992). The presence of *L. brebissonii* in North America was only recently recognized (Goward et al. 1994a). The known North American distribution consists of a single site in southeastern Alaska at Wrangell (Geiser et al. 1998), a few sites in coastal British Columbia in the Queen Charlotte Islands, and near Ucelot (Goward 1996), a single site in Washington, and a few scattered sites in Oregon.

In the range of the Northwest Forest Plan, *L. brebissonii* is known from eight sites in Oregon and one on the Olympic Peninsula (Jefferson County north of Queets) in Washington. Six of the eight documented sites in Oregon are on federal land. Five known sites occur on the Siuslaw NF: Eel Creek Campground

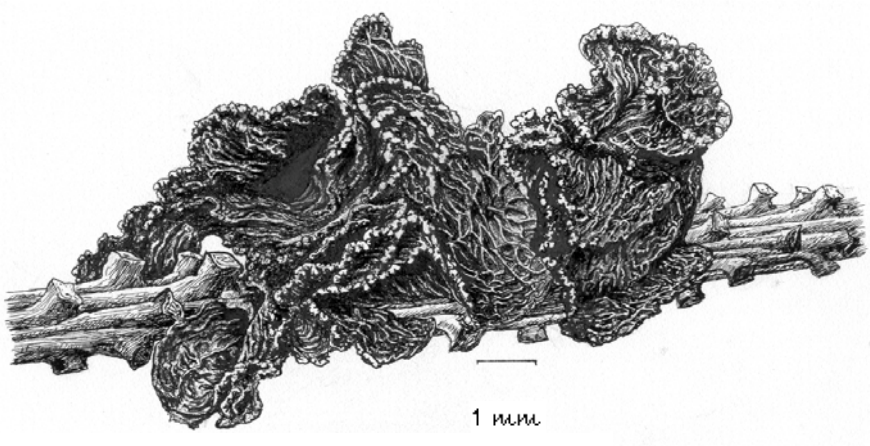

Figure 15. Drawing of *Leptogium brebissonii.*

in Oregon Dunes National Recreation Area (NRA) (Coos County); Sutton Creek Campground on the Mapleton Ranger District (Lane County); a ridge crest above Cedar Creek on the Hebo Ranger District (Lincoln County); and two locations in the Cascade Head Experimental Forest (Tillamook County). It occurs at Eugene District BLM Heceta Dunes Area of Critical Environmental Concern (ACEC) (Lane County). Small populations were found in Carl Washburne Memorial State Park (Lane County) and on the summit of Neahkahnie Mountain in Tillamook County (McCune *et al*. 1997b).

D. Habitat Characteristics and Species Abundance

This lichen is typically found in moist, semi-exposed habitats, close to the ocean, on trees or shrubs. Outside North America, it has also been found on mossy rocks. In British Columbia, it is thought to be closely associated with old-growth (Goward 1996). In the range of Northwest Forest Plan, because of sparse distribution and the diverse nature of known habitats, the degree to which it is associated with late-successional or old-growth forests is undetermined.

All known sites of *L. brebissonii* are within 16 km (10 mi) of the coast, from sea-level to 600 m (2000 ft) elevation. Coastal fog may be an important habitat condition. It grows in semi-exposed conditions such as tree pockets on stabilized dunes, wetland shrubs, deciduous trees in riparian zones, and open-grown trees and partially thinned stands on ridgetops. Known substrates in the Pacific Northwest are Sitka spruce (*Picea sitchensis*), red alder (*Alnus rubra*), Pacific rhododendron (*Rhododendron macrophyllum*), huckleberry (*Vaccinium* spp.), and Hooker's willow (*Salix hookeriana*). In British Columbia and southeastern Alaska, *L. brebissonii* has been found on cascara (*Rhamnus purshiana*) and red alder in open, low elevation hypermaritime forests and beach edges (Goward et al. 1994b, Geiser et al. 1998). In western Europe, it also occurs on mossy rocks (Purvis et al. 1992).

At the summit of Neahkahnie Mountain about 1 km (0.6 mi) from the ocean., *L. brebissonii* was found on twigs at the top of a Sitka spruce on an exposed, rocky ridgetop with moss-covered basalt outcrops and pockets of Sitka spruce forest. At Nescowin Creek, it was found on twigs of Sitka spruce in a Sitka spruce/red alder forest. At the mouth of Cliff Creek in Cascade Head Experimental Forest, it was found on the bark of red alder in a young Sitka spruce/western hemlock (*Tsuga heterophylla*) forest. At the ridge crest above Cedar Creek, also on the Hebo District, it was found in a thinned western hemlock/salmonberry-salal (*Rubus spectabilis-Gaultheria shallon*) forest of young and mature trees. In Carl Washburne Memorial State Park it was found on Sitka spruce at the forest edge. In Sutton Creek Recreation Area, *L. brebissonii* was found at a semi-exposed site on old rhododendron adjacent to the edge of an old Sitka spruce-shore pine (*Pinus contorta*)/evergreen huckleberry (*Vaccinium ovatum*) forest on stabilized dunes, and on evergreen huckleberry. At the Heceta Dunes sites it was found on Hooker's willow near vernal pool lowlands; on a willow branch in a shady thicket of the dune and interdune wetlands with broken Sitka spruce-shore pine/evergreen huckleberry forest and cyanolichen-rich willow and ericaceous shrub thickets; and in willow/sweet gale (*Myrica gale*) wetland thickets and open-grown conifers adjacent to thickets. At Eel Creek, it was found in a shore pine/*Arctostaphylos* woodland.

Physiologically, epiphytic cyanolichens are not considered tolerant of extreme swings in humidity or temperature. They are characteristically found in the wettest microsites: over moss at the bases of trees, or in the canopy on inner, protected branches of trees. Unlike many lichens with a green algal photobiont, cyanolichens must be fully hydrated to photosynthesize (Nash 1996). The availability of moderated microsites is an important factor in the high biomass of cyanolichens in riparian areas and many older forests west of the Cascade crest. Presumably, frequent fog provides favorable moisture conditions for coastal cyanolichens.

II. CURRENT SPECIES SITUATION

A. Why Species is Listed Under Survey and Manage Standard and Guideline

L. brebissonii was thought to be at risk under the Northwest Forest Plan because of its rarity and limited distribution within the range of the northern spotted owl (USDA and USDI 1994a, 1994b). At the time of the lichen viability panel, this species was known from only one site in the range of the northern spotted owl (USDA and USDI 1994a, 1994b). Ratings by the viability panel reflected a high level of concern for this species. The rare oceanic-influenced lichens as a group received the lowest viability ratings among all the lichens considered (USDA and USDI 1994a).

Because of the low viability ratings and high level of concern, this species was identified as a Survey and Manage Strategy 1 and 3 species (USDA and USDI 1994c), with the dual objectives of managing known sites and conducting extensive surveys to find additional populations and identify other high-priority sites for species management.

B. Major Habitat and Viability Considerations

Frequent fog, and various ocean-influenced climatic, vegetative and soil factors, appear to be important factors influencing the distribution of *L. brebissonii*. Suitable habitats are sparse and are often separated by many miles. Given the limited availability of habitat, the high rate of human and natural disturbance to these habitats, and the slow colonization rates of *L. brebissonii* (no large populations have been recorded), it seems likely that this species will continue to be rare within the range of the Northwest Forest Plan.

The major concerns for *L. brebissonii* are the small number of known sites, the limited amount of suitable habitat for this species on federal land, and loss of populations from human activities that directly affect the remaining populations, habitat areas, or potential habitat. Climate changes, especially if they affect coastal fog regimes, and air pollution, are secondary concerns. Degradation or change in habitat conditions could affect the vigor of this species, possibly resulting in an even more restricted distribution or contributing to local extirpation.

Isolation of populations also leads to genetic isolation. Almost nothing is known about the genetics of lichen populations or the effects of gene pool isolation on local extinction rates of populations.

C. Threats to the Species

Threats to *L. brebissonii* are those actions that disrupt stand conditions necessary for its survival. Such actions include treatments that reduce local populations by removing colonized bark or wood substrates; decreasing exposure to light; adversely affecting integrity of habitat areas; reducing or fragmenting potential habitat; or degrading air quality.

Recreational activities and developments may inadvertently alter the habitat of this species. Trampling by recreational vehicles and frequent foot traffic are serious threats, especially in shore pine woodlands and

edge communities, as these degrade the habitat by disturbing fragile root systems of trees and shrubs, and the fragile protective mats of ground cryptogams, which stabilize the soil (Christy et al. 1998). Destabilization of the foredunes by recreationists or removal of European beachgrass (*Ammophila arenaria*) can destabilize tree island habitats of *L. brebissonii* by increasing the amount of sand drift into them and burying trees on the perimeter (Christy et al. 1998). Buildings, roads, campgrounds and trails along the immediate coast have replaced many natural habitats to improve access, facilitate scenic views, or develop recreational uses.

Other threats to the integrity of habitat and potential habitat areas include logging, grazing, agriculture, and activities which alter local hydrology, or increase fire frequency (Christy et al. 1998). Concern about fire varies— many different plant communities and successional stages exist among the coastal dunes and headlands; fire is beneficial to some communities but damaging to others. Invasion or planting of exotics such as Scots broom (*Cytisus scoparium*), European beachgrass, tree lupine (*Lupinus arboreus*), birdsfoot-trefoil (*Lotus corniculatus*), and iceplant (*Mesembryanthemum* spp.) can have profound effects on nitrogen-poor dune soils by increasing nitrogen and soil moisture. These conditions foster invasion of other weeds, eventually disrupting native plant communities (Christy et al. 1998) and reducing plant and animal diversity (USDI 1997).

Like other epiphytic cyanolichens, members of the genus *Leptogium* are considered very sensitive to air pollution (Wetmore 1983, Insarova et al. 1992, McCune and Geiser 1997). Although air quality is relatively good at known sites, increased pollution emissions from increased traffic and new or expanded industry along the coast may threaten this species. Pollutants of most concern are SO_2, NO_x, and acid deposition containing sulfur and nitrogen compounds.

Climate change affecting coastal fog patterns could be expected to affect the vigor of this species, possibly resulting in an even more restricted distribution or contributing to local extirpation.

D. Distribution Relative to Land Allocations

L. brebissonii is known from six sites on federal land. The two sites in Cascade Head Experimental Forest and the population at Eel Creek Campground in the Oregon Dunes National Recreational Area are Congressionally withdrawn for research and recreational emphases, respectively. Sutton Creek Campground on the Mapleton Ranger District is administratively withdrawn as a recreation area. The site at Cedar Creek on the Hebo Ranger District is in a late-successional reserve. The Eugene District BLM Heceta Dunes ACEC is administratively withdrawn.

III. MANAGEMENT GOAL AND OBJECTIVES

A. Management Goal for the Species

The goal for managing *L. brebissonii* is to assist in maintaining species viability.

B. Objectives

Manage populations at all known sites by maintaining habitat and suitable habitat immediately surrounding known populations.

IV. HABITAT MANAGEMENT

A. Lessons From History

Habitat destruction or alteration has made a significant contribution to the decline of lichens world-wide (Seaward 1977). Rare lichens that are limited to habitats optimal for human activities, such as *L. brebissonii*, are especially vulnerable. In coastal Oregon, activities of the past 140 years: increased fire, agriculture, and grazing, logging, changes in hydrology and recreation have affected plant succession in a major way (Christy et al., 1998). At Sand Lake dunes of Oregon, a hotspot for lichen diversity, off-road vehicles have destroyed nearly all the shore pine woodlands in just thirty years (Wiedemann 1984, 1990 as cited by Christy et al. 1998). At the northern Samoa Peninsula, the native dune communities have been nearly eliminated by the invasion of European beachgrass and human activities, and only a tiny fragment of the dune forest remains (Glavich, pers. comm.). At the Lanphere Dunes Unit, even hiking has been documented to damage fragile shore pine/bearberry (*Arctostaphylos uva-ursi*) communities (Brown 1990).

Lichens have been known to be sensitive to air pollution for more than a century. Many species in Europe (Ferry et al. 1973, Hawksworth and Rose 1976) and the eastern United States (Brodo 1966, Showman and Long 1992, McCune et al. 1997a) are in an active state of decline from sulfur dioxide, nitrogen oxides, and acidic deposition of sulfur- and nitrogen-containing pollutants. Fog contains more dissolved ions and acidity than precipitation does (James and Wolseley 1992). Lichens that obtain most of their water from fog and dew are particularly vulnerable to air quality and weather pattern changes (Nash 1996). Follmann (1995) documented massive impoverishment and retrogression of lichens over much of the northern Chilean coastal fog belt over the past 20 years. Increasing frequency of El Niño events and gradually increasing aridity were postulated as likely, but not exclusively, causal factors in this decline. In the Pacific Northwest, sensitive species are already declining in some areas (Denison and Carpenter 1973, Taylor and Bell 1983) and lichens have been identified as Air Quality Related Values in USDA Forest Service regional air resource management guidelines (Peterson et al. 1992).

B. Identifying Habitat Areas for Management

All known sites of *L. brebissonii* on federal lands administered by the Forest Service and BLM in the range of the Northwest Forest Plan are identified as habitat areas where these management recommendations should be implemented. A habitat area for management is defined as suitable habitat occupied by or near a known population.

C. Management Within Habitat Areas

The objective of managing in habitat areas is to maintain the habitat conditions for *L. brebissonii.* Sites with known populations should be managed to include an area large enough to maintain the habitat and associated microclimate of the population.

- Determine the extent of the local population and habitat area with a site visit.
- Maintain suitable habitat around the current host trees and shrubs, so that the lichen may have adequate new substrate as current substrates decline.
- Develop practices to route human use away from the populations in habitat areas (e.g., divert roads, trails and off-road vehicles). Trampling shrubs or cryptogam mats, compacting roots, damaging trees or branches that serve as substrates, introducing non-native species by seed dispersal or planting, can all adversely affect habitat integrity.
- Avoid harvesting trees, shrubs, or other vegetation from the population and habitat area unless these actions would do no harm to, or would improve, the habitat for *L. brebissonii* (e.g., to prevent deeply shaded conditions or remove invasive exotics).
- Restrict commercial collection of moss or fungi or other special forest products if these activities would adversely affect the integrity of habitat areas.
- Prevent fire in the population but utilize or prevent fire in habitat areas, depending on the role of fire in the plant community. Consider recommendations by Christy et al. (1998) for fire management and prescribed fire in coastal plant communities.

- Maintain integrity of the foredunes or other coastal features where they protect habitat areas.

D. Other Management Issues and Considerations

- Consider opportunities for managing known sites during Forest Plan and Resource Management Plan revisions, such as Botanical Special Interest Areas, Areas of Critical Environmental Concern, or other administratively withdrawn designations, or by prescribing special standards and guidelines.
- Share information with State and private sectors to further activities directed at conserving *L. brebissonii.*
- Continue to work with state and federal regulatory agencies to protect air quality on federally-managed lands from on- or off-site emissions, especially of nitrogen- and sulfur-containing pollutants.
- Provide information about conserving rare lichens at visitor centers or other locations along the coast to build public support of conservation efforts and to discourage collection of specimens.

V. RESEARCH, INVENTORY, AND MONITORING NEEDS

The objective of this section is to identify opportunities to acquire additional information that could contribute to more effective species management. The content of this section has not been prioritized or reviewed as to how important the particular items are for species management. The inventory, research, and monitoring identified below are not required. These recommendations should be addressed by a regional coordinating staff.

A. Data Gaps and Information Needs

- Visit known sites to determine the extent of local populations, describe their habitat, and to clarify the association of this species with late-successional or old-growth forests.
- Determine if *L. brebissonii* meets the criteria for being closely associated with late-successional or old-growth forests.
- Determine whether additional populations exist in areas identified as potential suitable habitat. Known habitat conditions for *L. brebissonii* are coniferous and deciduous trees and shrubs in semi-exposed conditions such as tree pockets on stabilized dunes, trees on the edge of dune forests, dune woodlands, wetland shrub mosaics, deciduous trees in riparian zones, and open forested stands on ridgetops from sea level to 600 m (2000 ft) elevation, and within 16 km (10 mi) of the ocean.
- Assign priority to Strategy 3 surveys in areas where management treatments or projects are scheduled or proposed.

B. Research Questions

- What are the dispersal and growth rates of *L. brebissonii*?
- Which habitat characteristics are necessary for colonization by *L. brebissonii*? Are conditions unique to late-successional or old-growth forests critical to the survival of this species?
- Can stands be managed to mimic those characteristics?
- What are the minimum and optimum patch sizes of colonized habitat necessary to provide for *L. brebissonii*?

C. Monitoring Needs and Recommendations

- Monitor dispersal and population trends of existing populations.

Leptogium brebissonii

- Monitor known sites for changes in micro-climatic conditions, successional changes, and for inadvertent habitat damage from human activities or wildfire.
- Monitor air quality near key populations of *L. brebissonii* on federal lands and assess threats to this species from present or projected air-quality trends.

Leptogium rivale

SUMMARY

Species: *Leptogium rivale* Tuck.
Taxonomic Group: Lichens (Aquatic)
ROD Components: 1, 3

Other Management Status: None

Range: *Leptogium rivale* is known from only 14 sites in the range of the Northwest Forest Plan, seven in Washington and seven in Oregon. All sites are on National Forest lands except the Fidalgo Island site, which is of unknown ownership. In Washington, six sites are on the Gifford Pinchot National Forest, and one on Fidalgo Island. In Oregon, the species is found on the Willamette and Mount Hood NFs. *L. rivale* is endemic to western North America, known from California, Oregon, Washington, Alaska, Wyoming, Montana, and northern Colorado.

Specific Habitat: This aquatic lichen is primarily found on rocks submerged in water or in the splash or inundation zone of small-order, clear mountain streams, and in a coastal freshwater seep.

Threats: The major threats to *L. rivale* are loss of populations resulting from activities that harm the population or affect its habitat, including impacts from upstream sites. Altering stream conditions such as water quality, chemistry, temperature, light regime, level, opacity, or sediment levels, or changing micro-climatic conditions in the associated riparian vegetation are all potential threats. Road building and decommissioning (including culvert placement and removal), restoration activities, and fish habitat enhancement projects involving instream structures are also potential threats.

Management Recommendations:
- Because dispersal may be limited between streams, maintain *L. rivale* in each stream where it occurs.
- Maintain stream quality necessary for survival of *L. rivale*.
- Maintain riparian canopy conditions necessary for survival of *L. rivale*.

Information Needs:
- Determine if the species meets the criteria for being closely associated with late-successional or old-growth forests.
- Verify current status of known populations.
- Determine the stream conditions necessary for survival of *L. rivale*.
- Determine if individuals in stream represent more than one local population.
- Determine the natural range of riparian canopy conditions necessary for survival.

Leptogium rivale

I. NATURAL HISTORY

A. Taxonomy and Nomenclature

Leptogium rivale Tuck. was described in 1877 (Proc. Am. Acad. 12:170).

Synonym: *Polychidium rivale* (Tuck.) Fink *n. comb.* (Fink 1935).

B. Species Description

1. Morphology

L. rivale is a small, appressed, foliose gelatinous aquatic lichen (**Figure 16**). The lobes are more or less flat with somewhat raised tips; apothecia are occasional with brownish black discs and thalline rims. At first glance, the species looks like a circular black crustose lichen, and could be confused with *Verrucaria* or *Staurothele*. These two genera are truly crustose; examination with a hand lens would reveal the minute foliose lobes in *L. rivale*. The thallus is lead gray or greenish-gray to blackish. Older thalli occasionally become lobulate. This lichen can be very hard to see.

Technical Description: Thallus 0.5-2.0 cm broad, flat, spreading, tightly appressed with margins occasionally ascending, lead gray or greenish gray to blackish; lobes elongate, the rounded apices 0.2-1.5 mm broad, the margins entire to somewhat irregularly lobulate; surface of thallus smooth, shiny or dull; isidia not present; attached to the substrate by numerous black hairs on the lower surface. Thallus 45-150 μm thick; cortex of irregularly isodiametric cells 3-9 μm in diameter, commonly brownish or blackish, cells of the lower cortex slightly larger than those of the upper cortex; thallus paraplectenchymatous throughout. Photobiont is *Nostoc*; these cyanobacterial cells are 2-4 μm in diameter, spherical, and in short chains throughout the thallus but not abundant. Apothecia not common, adnate on the upper surface of the thallus, 0.2-0.4 mm broad; disc concave, brownish to blackish (Sierk 1964:272).

2. Reproductive Biology

L. rivale reproduces sexually by production of fungal spores in apothecia. Because the species is aquatic, the spores are probably distributed primarily by flowing water. Aquatic invertebrates that graze on this lichen and ingest spores could also be dispersal vectors, as could the downstream movement of colonized rocks. Isidia and soredia are unknown, although some older thalli do produce lobules that may drift to new sites and reattach to rocks.

3. Ecological Roles

Little is known about the ecological roles of this freshwater species. It fixes nitrogen and contributes an unknown amount to aquatic ecosystems. *L. rivale* probably provides forage and cover for some aquatic invertebrates, which in turn are food for fish. Many invertebrates, including protozoans, nematodes, rotifers and tardigrades, use aquatic lichens as food and habitat (Gerson and Seaward 1977). *H. venosa*, another nitrogen-fixing aquatic lichen, is often present at sites with *L. rivale*. Aquatic lichens may be good indicators of water quality (USDA and USDI 1994b.).

C. Range and Known Sites

L. rivale is known from only 14 sites in the range of the Northwest Forest Plan, seven each in Washington and Oregon. All sites are on National Forest lands except the site on Fidalgo Island, which is of unknown ownership. In Washington, *L. rivale* is known from the Gifford Pinchot NF on McKinley, Snagtooth, and Platnum Creeks, an unnamed tributary on the 2588 road, and from Government Mineral Springs (Skamania County). In Oregon, it is known from the Willamette NF near Opal Creek, near North

Santiam River, and from the H.J. Andrews Experimental Forest (Marion and Lane Counties), and Mt. Hood NF near Skipper Creek and the trail to Tamanawas Falls (Hood River County). *L. rivale* is endemic to western North America (Sierk 1964), known from California, Oregon, Washington, Alaska, Wyoming, Montana, and northern Colorado. Although it has been found at one site in Southeast Alaska (Geiser et al. 1998), it is not yet known from British Columbia (Goward et al. 1994).

Figure 16. Drawings of *Leptogium rivale.*

D. Habitat Characteristics and Species Abundance

In the range of the Northwest Forest Plan, *L. rivale* is found in mid-elevation streams between 105-1980 m (1000-6500 ft) on rocks, boulders, and bedrock in streams, rivers, or seeps, usually submerged or inundated for most of the year. In larger rivers with higher flows, it grows on the sides and downstream edges of in-stream bedrock, where it apparently receives some protection from the direct force of the water. It is also reported from a coastal freshwater seep. *L. rivale* can be locally abundant, although its distribution in the range of the Northwest Forest Plan is scattered and the species is apparently rare. This small, black, closely appressed lichen, which looks like black splotches on rocks, can be very hard to see, which could contribute to our limited sites for the species. The lack of records in our area could be because it is inconspicuous and may have been confused with *Verrucaria* or *Staurothele*, and/or it has been under-collected.

II. CURRENT SPECIES SITUATION

A. Why Species Is Listed Under Survey and Manage Standard and Guideline

L. rivale was considered at risk under the Northwest Forest Plan because of its rarity and limited distribution in the range of the northern spotted owl (USDA and USDI 1994a,b). At the time of the FEMAT viability rating, it was only known from two sites in the range of the northern spotted owl (USDA and USDI 1994b).

B. Major Habitat and Viability Considerations

The major viability consideration for *L. rivale* is loss of populations resulting from management activities that harm the populations or impact their habitat.

C. Threats to the Species

Threats to *L. rivale* are those actions that alter stream conditions, including water quality, including chemistry, temperature, light regime, level, opacity, sediment loading and streambank stability, or alter

micro-climatic conditions associated with riparian vegetation. Building and decommissioning roads (including culvert placement and removal) and restoration activities also pose a threat when they degrade colonized stream segments, or produce sediments that harm downstream populations. Run-off of fertilizers could also threaten some populations. Aquatic ecosystems are particularly responsive to chemical stress because pollutants tend to be well-distributed throughout zones of active mixing (Ford 1989).

D. Distribution Relative to Land Allocations

All known sites of *L. rivale* on federal lands are in Riparian Reserves (USDA and USDI 1994c). The adjacent land allocations need to be determined.

III. MANAGEMENT GOAL AND OBJECTIVES

A. Management Goal for the Species

The goal for managing *L. rivale* is to assist in maintaining species viability.

B. Objectives

Manage known sites on federal lands by maintaining habitat, stream conditions, riparian forest structure and associated microclimate, as well as occupied and potentially suitable substrate.

The objective of management for *L. rivale* is to maintain population viability at each known site.

IV. HABITAT MANAGEMENT

A. Lessons from History

No specific lessons from history about *L. rivale* are known.

B. Identifying Habitat Areas for Management

All known sites of *L. rivale* on federal land in the range of the Northwest Forest Plan are identified as habitat areas where these management recommendations should be implemented. A habitat area is identified as suitable habitat occupied by or adjacent to a known site.

C. Managing in Habitat Areas

Although *L. rivale* is restricted in its distribution, there may be certain areas where it is locally common. If a population of *L. rivale* occurs in a project area, several factors should be evaluated before proceeding with actions that could adversely impact the local population. Evaluate the importance of that population in relation to other known sites. Consider the landscape and ecological context of the population, factors such as the population location in relation to other known populations, relative isolation of the population, ecological conditions at the site and how they compare to other known sites (typical or atypical), areal extent of the population and abundance of the lichen in the local population, and availability of potentially suitable habitat in the area.

Each local population should be maintained intact, however it may be acceptable to impact a small percentage of known individuals at a particular site if it has only minimal impact to the integrity of the local population. Special consideration should be given to populations near the edge of range of *L. rivale*,

in watersheds where it is rare and of limited distribution.

After evaluating these considerations, and if a decision has been made to impact the local population in a project area, apply the following mitigation measures. Visit the site with a project coordinator to determine if proposed actions can be shifted upstream or downstream so large concentrations of individuals are not impacted. If impacts are unavoidable, determine if any of the colonized rocks are small enough to be transplanted to suitable habitat above the project area. Transplant as many colonized rocks as possible, and monitor their vigor (Derr 1998).

- Because there may be dispersal limitation between streams, maintain *L. rivale* in each stream where it occurs.
- Determine the extent of local population with a site visit.
- Maintain habitat for the species at known sites on federal lands by maintaining stream conditions including water quality, chemistry, temperature, level, opacity, or sediment loading and streambank stability, and maintaining micro-climatic conditions (e.g., light regime) associated with riparian vegetation.
- Reduce sedimentation into populated streams by minimizing or eliminating impacts of road building, maintenance, and decommissioning (including culvert placement and removal) and restoration activities.
- Evaluate upstream activities that could affect downstream populations.
- Evaluate effects from treatments to riparian vegetation and the potential for altered bank stability, sediment and nutrient input, and how known sites of *L. rivale* could be affected by those activities.
- Avoid the use of fertilizers and herbicides near populated streams, including upstream reaches.

D. Other Management Issues and Considerations

L. rivale provides habitat for aquatic invertebrates (USDA and USDI 1994a). Declines in populations could impair ecological functions important to fish and other components of aquatic and terrestrial ecosystems. *L. rivale* fixes nitrogen and contributes an unknown amount of nitrogen to aquatic ecosystems; removing a population could have unknown effects on the nutrient cycles of the stream. The species is thought to be an indicator of water quality (USDA and USDI 1994b) and may be sensitive to changes in water chemistry, temperature, light regime, level, opacity, or sediment load. Known sites should be evaluated at the sub-basin scale because activities far from the population may adversely affect the population if they alter upper reaches of an occupied stream. If populations of *L. rivale* are in a project area, evaluate its distribution and abundance in that stream. Because dispersal may be limited between streams, it is important to maintain *L. rivale* in each stream where it occurs. If the species is well distributed in the stream above a project area, evaluate suitable habitat below the project area, and the likelihood that *L. rivale* will be able to repopulate areas impacted during projects. The highest priority should be given to those populations where management activities may alter stream hydrology or aquatic conditions.

V. RESEARCH, INVENTORY, AND MONITORING NEEDS

The objective of this section is to identify opportunities to acquire additional information that could contribute to more effective species management. The content of this section has not been prioritized or reviewed as to how important the particular items are for species management. The inventory, research, and monitoring identified below are not required. These recommendations should be addressed by a regional coordinating staff.

Leptogium rivale

A. Data Gaps and Information Needs

- Revisit known sites to verify the status of known populations, determine the extent of the populations and abundance, and characterize ecological conditions.
- Determine if the species meets the criteria for being closely associated with late-successional or old-growth forests.
- Determine the natural range of riparian canopy conditions necessary for survival of *L. rivale*.

B. Research Questions

- What are the dispersal rates, distances, and mechanisms of *L. rivale*?
- Which habitat characteristics and ecological conditions are necessary for establishment of propagules and survival of established thalli?
- In colonized streams, how does cover of *L. rivale* fluctuate seasonally, annually, or between flood events?
- Can *L. rivale* survive transplanting of colonized rocks to different parts of the parent stream and to different streams?
- How should populations be distributed in a stream to optimize recolonization into lower stream reaches?
- How do *L. rivale* and aquatic insects interact?
- What is the ecological role of *L. rivale* in aquatic and adjacent terrestrial ecosystems?
- Do refugial populations colonize lower stream reaches?

C. Monitoring Needs and Recommendations

- Monitor populations at sites of restoration activities, road building and decommissioning (including culvert removal or placement).
- Monitor transplanted populations for changes in cover, biomass, and vigor.
- Monitor streams for dispersal of *L. rivale* where it has been reintroduced.

Lobaria hallii

SUMMARY

Species: *Lobaria hallii* Zahlbr.
Taxonomic Group: Lichens (Rare Nitrogen-fixing)
ROD Components: 1, 3

Other Management Status: None

Range: *Lobaria hallii* is widespread in the area of the Northwest Forest Plan with nearly 100 reported sites. Known sites on federal land in Washington are on the Mt. Baker-Snoqualmie, Wenatchee and Gifford Pinchot NFs; Mt. Rainier National Park; and Carson National Fish Hatchery. Federal sites in Oregon are on the Mt. Hood, Siuslaw, Willamette, Umpqua, Siskiyou, and Deschutes NFs; BLM Camas Swale Research Natural Area; BLM Eugene District; and Finley National Wildlife Refuge. Known sites on federal land in California are on the Shasta-Trinity and Six Rivers NFs, and BLM land at Black Oak Mountain.

Specific Habitat: In the area of the Northwest Forest Plan, *L. hallii* has a broad ecological distribution, and has been documented in a diversity of habitats and on various substrates. It is found in wetlands, swales and riparian areas, orchards, meadows and low elevation forests to dry upland forests and ridgetops, oak savannahs and rocky balds. This species is found in wet to dry sites, and ranges from 55-1690 m (180-5540 ft) in elevation. *L. hallii* grows in a wide range of stand ages and successional stages, from young to mature stands, and disturbed forests. It occasionally occurs in older stands, yet does not appear to be a species closely associated with late-successional or old-growth forests. It tends to be more restricted in its ecological amplitude to the east and south in the area of the Northwest Forest Plan, and has a broader ecological amplitude west of the Cascade crest in Oregon and Washington than on the east side of the Cascades.

Threats: Threats to *L. hallii* are those actions that disrupt stand conditions necessary for its survival, including treatments affecting populations, such as removing colonized substrate, stand treatments that change the microclimate or forest structure that make the site no longer suitable for *L. hallii* to survive, and possibly a deterioration in air quality. In northern California, a potential threat to local populations is the harvest of oak for firewood.

Management Recommendations:

- Manage populations of *L. hallii* at known sites by maintaining the ecological conditions associated with *L. hallii*, including forest structure, substrate and microclimate.
- Maintain a hardwood component in riparian stands where *L. hallii* occurs.

Information Needs:

- Determine if *L. hallii* is closely associated with late-successional or old-growth forests.
- Determine the air pollution sensitivity of *L. hallii*.

Lobaria hallii

I. NATURAL HISTORY

A. Taxonomy and Nomenclature

Lobaria hallii was described by Zahlbruckner in 1925 (Cat. Lich. Univ. 3:321). See Jordan (1973) for monographic treatment of *Lobaria* in North America. *L. hallii* is in the order Lecanorales, suborder Peltigerineae, family Lobariaceae (Tehler 1996).

Synonyms:

Stictina hallii (Tuck.) Stizenb. (Flora 81:126. 1895.)
Sticta hallii Tuck. (Proc. Amer. Acad. Arts 12:168. 1877.)

B. Species Description

1. Morphology and Chemistry

L. hallii is a large, showy, gray to brownish-gray foliose lichen. The upper cortex is coarsely ridged and with sparse tomentum, especially near the lobe tips, the lower surface is mottled pale brown or whitish and tomentose (**Figure 17**). This species is characterized by the presence of a blue-green primary photobiont, production of soredia, and the absence of stictic, norstictic, and usnic acids. *L. hallii* may be confused with *Lobaria scrobiculata*, but differs in chemistry and the presence of tomental hairs on the upper surface. Chemistry of *L. hallii* is cortex K+ yellow, KC-, and all medulla tests are negative. The thalli of *L. hallii* are steel gray and lack the yellow-green tinge typical of *L. scrobiculata* (Jordan 1973:240).

Technical Description: Thallus up to 11 cm broad, central portion firmly attached, coriaceous-cartilaginous, scrobiculate, sometimes smooth or ribbed; smoke gray to grayish-olive when dry, much darker when wet. Lobes large, broadly rounded and approaching flabelliform, up to 4 cm across; tips tending to be free and reflexed, pulverulent. Margins crenulate-undulate thickened in sorediate areas. Fine pale tomentum present on dorsal surface of young lobes, quantity variable. Soredia abundant on the lamellae, less so on the margins, becoming dark colored; soralia punctiform when young, finally confluent. Lobules and isidia absent. Lower surface with irregularly shaped, flat, naked areas separated by tomentose veins, which are often raised and "peltigeroid" in older portions. Lower cortex cream colored to citrine-drab, prominent veins dark olive. Tomentum darkening, present to margin; clusters of dark rhizines often abundant, to 3 mm long (Jordan 1973:238).

2. Reproductive Biology

L. hallii reproduces asexually by producing soralia, apparently its primary means of reproduction. It is rarely fertile; only 5% of the *L. hallii* thalli observed by Jordan (1973) for his North American monograph were fertile.

3. Ecological Roles

Little is known about the ecological roles of *L. hallii*, but it is known to fix atmospheric nitrogen.

C. Range and Known Sites

L. hallii is found in North America from Alaska south to northern California and east to western Montana (McCune and Goward 1995), with disjunct populations in Scandinavia and Greenland (Jordan 1973). *L. hallii* is widespread in the area of the Northwest Forest Plan with nearly 100 reported sites.

It is reported from Washington in Whatcom, Skagit, Snohomish, Pierce, Lewis, Skamania, Klickitat, and Chelan Counties; from Oregon in Clackamas, Hood River, Wasco, Jefferson, Deschutes, Yamhill, Benton, Marion, Lincoln, Jefferson, Linn, Lane, Douglas, and Josephine Counties; and from California in Butte, Del Norte, Trinity, Humboldt, Mendocino, and San Mateo Counties. Known sites on federal land in Washington are on the Mt. Baker-Snoqualmie, Wenatchee, and Gifford Pinchot NFs; Mt. Rainier National Park; and Carson National Fish Hatchery. Federal sites in Oregon are documented on the Mt. Hood, Siuslaw, Willamette, Umpqua, Siskiyou, and Deschutes NFs; BLM Camas Swale Research Natural Area; BLM Eugene District; and Finley National Wildlife Refuge. Known sites on federal land in California are on the Shasta-Trinity NF, Six Rivers NF, and BLM land at Black Oak Mountain.

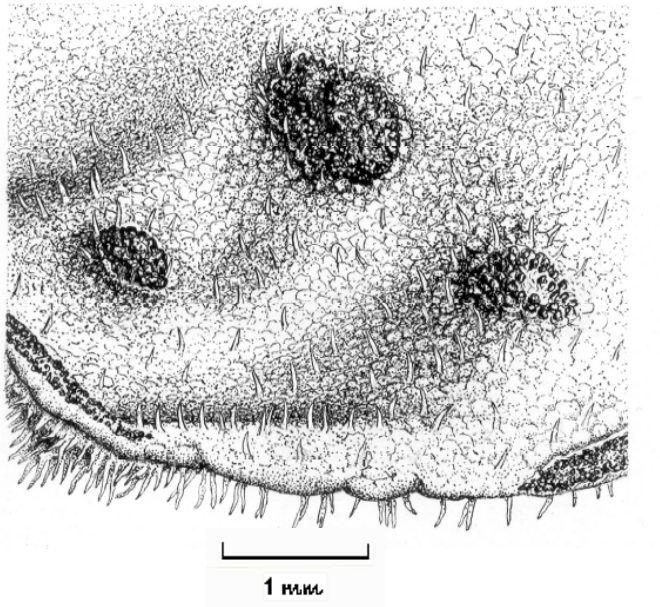

Figure 17. Drawing of the lobe tip of *Lobaria hallii.*

D. Habitat Characteristics and Species Abundance

L. hallii has a broad ecological distribution in the area of the Northwest Forest Plan. It is documented in a diversity of habitats and on various substrates throughout this region— from wetlands, swales and riparian areas, orchards, meadows and low elevation forests to dry upland forests and ridgetops, oak savannahs, and rocky balds. This species ranges from wet to dry sites and from 55-1690 m (180-5540 ft) elevation. *L. hallii* occurs in a wide range of stand ages and successional stages, from young to mature stands, and disturbed forests. It is sometimes found in older stands, yet it does not appear to be closely associated with late-successional or old-growth forests. Although widespread throughout this region, *L. hallii* is not common and may only be found in a portion of what appears to be suitable habitat. This species is generally rare where it occurs, but it may be locally abundant.

L. hallii is an epiphyte on a variety of trees and shrubs, including both angiosperms and conifers. It is more commonly found on hardwoods: black cottonwood (*Populus trichocarpa*), California black oak (*Quercus kelloggii*), Oregon white oak (*Quercus garryana*), Oregon ash (*Fraxinus latifolia*), bigleaf maple (*Acer macrophyllum*), vine maple (*A. circinatum*), alder (*Alnus* spp.), willow (*Salix* spp.), hazelnut (*Corylus cornuta*), fruit trees and various shrubs. *L. hallii* also grows on a variety of conifer species including Douglas-fir (*Pseudotsuga menziesii*), Pacific silver fir (*Abies amabilis*) and western white pine (*Pinus monticola*). This species has also been reported growing on an old wooden roof (probably western redcedar, *Thuja plicata*).

L. hallii appears more restricted in its ecological amplitude to the east and south in the area of the Northwest Forest Plan. East of the Cascade crest, *L. hallii* is primarily in moist, lowland riparian areas, often on deciduous trees such as black cottonwood, bigleaf maple and alder, and typically in sheltered, moist sites. Farther south into northern California, *L. hallii* is documented primarily as an epiphyte on California black oak and Oregon white oak in habitats such as oak savannah and grassland areas, and in Douglas-fir dominated stands. In these habitats, *L. hallii* is generally found in the more mesic microsites, and is typically associated with moss mats (*Antitrichia californica*, *Dendroalsia abietina*) and other cyanolichens (e.g., *L. pulmonaria, Pseudocyphellaria anthrapsis, P. anomala, Nephroma helveticum, Peltigera collina*) on the lower boles of older California black oak (L. Hoover, pers. comm.). Habitats of *L. hallii* in northern California are in various plant associations within the Black Oak and White Oak

Series, and within the following sub-series: Douglas-fir-Black-Oak, Douglas-fir-White Oak, Douglas-fir-Ponderosa Pine and White fir-Douglas-fir (L. Hoover, pers. comm.). Associated species include incense cedar (*Calocedrus decurrens*), hazelnut, madrone (*Arbutus menziesii*), ponderosa pine, bigleaf maple, ceanothus (*Ceanothus* sp.), and canyon live oak (*Q. chrysolepis*). *L. hallii* may also occur in riparian areas in northern California, although few surveys have been conducted for this species in riparian habitats.

L. hallii has a broader ecological amplitude west of the Cascade crest in Oregon and Washington, where it grows in a variety of different habitats from low elevation wetland and riparian areas to upland forests and dry sites of open woodlands, savannahs, and rocky balds. It grows on a diversity of hardwood and conifer substrates, both trees and shrubs. Specific habitats documented for this species include low-elevation riparian areas dominated by black cottonwood, bigleaf maple, or both; Oregon ash swales; Oregon white oak and Oregon ash stands; and riparian and low-elevation mesic forests of Douglas-fir, western hemlock and western redcedar. *L. hallii* has been documented in drier sites, including an open rocky bald near a cliff edge in a mixed stand of Douglas-fir and Oregon white oak, xeric meadow fringed with Oregon white oak and ponderosa pine, and in dry hillside forests dominated by Oregon white oak. *L. hallii* also grows in open sites such as meadows, pastures, and old orchards.

II. CURRENT SPECIES SITUATION

A. Why Species Is Listed Under Survey and Manage Standard and Guideline

L. hallii was considered at risk under the Northwest Forest Plan (USDA and USDI 1994a, 1994b). It should be noted that *L. hallii* was included in the group of rare nitrogen-fixing lichens for the purpose of the lichen viability panel (USDA and USDI 1994a). *L. hallii* is not rare like the other members of this group, and the rating for this group of species is probably lower than what would have been given for *L. hallii* if it were to have been rated individually. *L. hallii* has a widespread distribution and at the time was known from many low to mid elevation forests within certain moisture regimes (USDA and USDI 1994b). Viability concerns were also noted for this species because of its presumed sensitivity to air pollution, inferred from the known sensitivity of other nitrogen-fixing species, but the pollution sensitivity of *L. hallii* is unknown.

The concern for this species persistence under the Northwest Forest Plan is probably low. Persistence concerns may increase to moderate for populations in areas more susceptible to pollution effects, or for populations at the edge of the species' range or ecological tolerance. Information acquired since the original viability analysis (USDA and USDI 1994a) and additional species analysis for the FSEIS (USDA and USDI 1994b), provides many more locations for *L. hallii* than were previously known. *L. hallii* is listed as a Survey and Manage Strategy 1 and 3 species with objectives to manage known sites and to conduct surveys to identify high priority sites for management (USDA and USDI 1994c).

B. Major Habitat and Viability Considerations

The major viability consideration for *L. hallii* is loss of populations from management activities that affect the populations or their habitat. *L. hallii* has a broad ecological amplitude in the area of the Northwest Forest Plan; it grows in a variety of different habitats and moisture regimes, substrates, and seral stages, as well as in open sites and under disturbed conditions. This ecological amplitude suggests that *L. hallii* may be somewhat tolerant to changes in microclimate that result from stand treatments. This species may also respond differently across its range, so its response may be quite different depending on local habitat conditions and environmental factors, or characteristics of specific populations. Generalizing about responses of *L. hallii* to various treatments or effects is therefore difficult. If *L. hallii* is sensitive to air pollution, then populations in areas exposed to various pollutants may be at risk. Many

of the populations in riparian areas will likely be protected by riparian buffer provisions in the Aquatic Conservation Strategy (USDA and USDI 1994c).

C. Threats to the Species

Threats to *L. hallii* are those actions that disrupt stand conditions necessary for its survival, including treatments affecting populations, such as removing colonized substrate, stand treatments that change the microclimate or forest structure that make the site no longer suitable for *L. hallii* to survive, and possibly a deterioration in air quality. In northern California, a potential threat to local populations is the harvest of oak for firewood.

D. Distribution Relative to Land Allocations

The distribution of known sites of *L. hallii* relative to land allocations needs to be determined. Each administrative unit should evaluate the land allocations for known sites on lands within its jurisdiction, and share this information at the regional level.

III. MANAGEMENT GOAL AND OBJECTIVES

A. Management Goal for the Species

The goal for managing *L. hallii* is to assist in maintaining species viability.

B. Objectives

Manage known sites on federal lands by maintaining habitat, stand structure, occupied and potential suitable substrate, and micro-climatic conditions associated with *L. hallii*.

IV. HABITAT MANAGEMENT

A. Lessons From History

Many lichen species are known to be sensitive to air pollution, and lichen population declines attributed to air pollution have been documented in Europe and North America (Rao and LeBlanc 1967, Skye and Hallberg 1969, Hawksworth 1971, Ferry *et al*. 1973, Hawksworth and Rose 1976, Case 1980, Sigal and Nash 1983, Gilbert 1992). Many nitrogen-fixing species are especially sensitive to air pollution, particularly sulfur dioxide (Wetmore 1983). The pollution sensitivity of *L. hallii* is not known, however, based on the known sensitivity of other nitrogen-fixing lichens, *L. hallii* may also be affected by air pollution.

The decline of lichens in Europe has resulted in the development of lists of threatened species. Sweden has a "red list" of lichens that are threatened with extinction because of air pollution and habitat degradation (Thor 1990). *L. hallii* is listed as endangered on Sweden's Red List (Databanken for hotade arter och Naturvardsverket 1991). The International Association of Lichenology has recently initiated a listing of lichens threatened globally.

B. Identifying Habitat Areas for Management

Known sites of *L. hallii* on federal land administered by the Forest Service or BLM in the area of the Northwest Forest Plan are identified as habitat areas where these management recommendations apply. A habitat area for management is defined as suitable habitat occupied by or adjacent to a known population.

C. Managing in Habitat Areas

The objective of managing in habitat areas is to maintain suitable habitat for *L. hallii*. Habitat areas should be managed to include an area large enough to maintain the habitat and associated microclimate of the population, as well as colonized substrates.

- Determine the extent of the local population and habitat area with a field visit.
- Manage populations at known sites by maintaining the existing ecological conditions, including occupied substrate and associated microclimate and stand conditions.
- Restrict collection of specimens where the species is rare or of limited abundance.
- Minimize effects to substrate occupied by *L. hallii*.
- When using fire as a management tool, consider how to provide for maintenance or enhancement of habitat for *L. hallii*.
- Restrict collection of firewood in stands of oak if this activity is affecting the persistence of local populations.
- Populations of *L. hallii* on California black oak and Oregon white oak within conifer stands should be evaluated to determine the need to conduct thinning or selective harvest treatments to provide the stand structure and substrate required by this lichen. Thinning may be necessary to open the canopy and to reduce lateral branch closure of conifers and suppression of oaks. Avoid impacts to oak trees in the habitat area. If treatments are conducted in the habitat area, the California black oak and white oak should be retained in clumps.
- If *L. hallii* occurs in a riparian area where treatments are proposed, maintain a hardwood component in the riparian stand to provide substrate for *L. hallii*.
- Special consideration should be given to maintaining populations near the edge of the geographical range of *L. hallii*, in watersheds where it is rare and with limited distribution.
- In some watersheds, *L. hallii* may be locally abundant. In these areas, if a population of *L. hallii* is in a project area, evaluate several factors to determine the importance of the population in relation to other known sites, and the contribution of that population to the species' persistence. Consider the landscape and ecological context of the population— e.g., factors such as the location of the population relative to other known populations, its relative isolation, the ecological conditions of the site and how they compare to other known sites (typical or atypical), the areal extent of the population and the abundance of the lichen in the local population, and the availability of suitable habitat in the area. Each local population should be maintained intact, however, it may be acceptable to impact a small percentage of known individuals at a particular site if it has only minimal impact to the persistence of the local population.

D. Other Management Issues and Considerations

Information from reported sites suggests that *L. hallii* may not be closely associated with late-successional or old-growth forests. For a species to be appropriately listed as a Survey and Manage species, it must first meet the criteria established for designation as a species closely associated with late-successional or old-growth forests (USDA and USDI 1994a [Table IV-6] and 1994b). This issue should be addressed by a regional coordinating staff.

V. RESEARCH, INVENTORY, AND MONITORING NEEDS

The objective of this section is to identify opportunities to acquire additional information that could contribute to more effective species management. The content of this section has not been prioritized or reviewed as to how important the particular items are for species management. The inventory, research, and monitoring identified below are not required. These recommendations should be addressed by a regional coordinating staff.

A. Data Gaps and Information Needs

- Determine if *L. hallii* is closely associated with late-successional or old-growth forests following the criteria established in the FEMAT report.
- Revisit known sites to verify the status of known populations, determine the extent of populations and abundance, and characterize ecological conditions.

B. Research Questions

- How does *L. hallii* respond to forest clearing activities (thinning, harvesting, road building), particularly to changes in light, temperature, and moisture regimes?
- What are the dispersal mechanisms and dispersal distance of *L. hallii*?
- Which habitat characteristics and ecological conditions are necessary for establishment of *L. hallii* propagules and survival of established thalli?
- What limits dispersal and establishment of propagules and colonization of suitable habitat?
- What are the minimum and optimum patch sizes of colonized habitat necessary to provide for *L. hallii* after timber harvest and thinning?
- How should refugial patches be distributed across the landscape to optimize recolonization into managed stands?
- Is *L. hallii* sensitive to air pollution?
- What is the genetic diversity of this species within its local populations and across the region?

C. Monitoring Needs and Recommendations

If management treatments are planned near known sites, monitor populations to determine the response to treatment and effects on the local population.

Lobaria hallii

Lobaria linita

SUMMARY

Species: *Lobaria linita* (Ach.) Rabenh.
Taxonomic Group: Lichens (Rare Nitrogen-fixing)
ROD Components: 1, 2, 3

Other Management Status: Oregon Natural Heritage Program List 2 (threatened with extirpation or presumed to be extirpated from the State of Oregon). Natural Heritage Network Ranks Oregon State Rank S1 (critically imperiled because of extreme rarity or because it is somehow especially vulnerable to extinction or extirpation, typically with 5 or fewer occurrences). Global Rank G4 (not rare and apparently secure, but with cause for long-term concern, usually with more than 100 occurrences) (Oregon Natural Heritage Program 1998). BLM Bureau Assessment Status in Oregon (USDI, BLM 1998).

Range: *Lobaria linita* has been documented from more than 50 sites in the range of the northern spotted owl. Most known sites are on federal lands; the vast majority occur in northwestern Washington on the Mt. Baker-Snoqualmie and Olympic NFs. It has also been documented on the Wenatchee and Mt. Hood NFs. The southern limit of *L. linita* is in question; reported sites from northern California and northern Oregon need verification.

Specific Habitat: In the range of the northern spotted owl, *L. linita* is reported between 550-2042 m (1800-6700 ft) elevation. Typical habitats of *L. linita* in northwestern Washington are cool and humid, mesic to moist, old-growth to climax forests in the Pacific Silver Fir or Mountain Hemlock Zones, where the species is an epiphyte most commonly on the base of Pacific silver fir boles, or on cool, shaded, moss-covered boulders or rock outcrops. In Oregon, it is reported from mature to old-growth forests in the Western Hemlock Zone. Habitat for the two sites in California is reported as oak forest with rock outcrops, and late-mature tanoak and madrone forest. When present, this species is not abundant, and occupies only a small portion of what appears to be suitable habitat.

Threats: The major threat to *L. linita* is loss of populations caused by activities that affect the habitat or the population, including removal of colonized substrate and alteration of microclimate. As a nitrogen-fixing species, *L. linita* may be sensitive to air pollution.

Management Recommendations: Maintain populations of *L. linita* at known sites by maintaining the ecological conditions, including undisturbed forest structure, substrate and interior forest microclimate. Restrict thinning or other stand treatments that will alter stand microclimate.

Information Needs:

- Verify the current status of known populations.
- Revisit the sites reported for Oregon and California to determine if the identification was correct; these populations appear as outliers both geographically and ecologically.
- Determine the distribution and extent of populations, species abundance, and ecological requirements of *L. linita* in the range of the northern spotted owl.

I. NATURAL HISTORY

A. Taxonomy and Nomenclature

Lobaria linita (Ach.) Rabenh. (Deutschl. Kryptogam Fl. 2:65, 1845) was first described by Acharius as *Sticta linita*. Two varieties are sometimes recognized, *L. linita* var. *linita* and *L. linita* var. *tenuior*, based on habitat and morphological differences (Jordon 1973). *L. linita* is in the order Lecanorales, suborder Peltigerineae, family Lobariaceae (Tehler 1996).

Synonyms:

Sticta pulmonaria var. *linita* (Ach.) Nyl.
Sticta linita Acharius
Sticta pulmonaria var. *linita* Nylander

B. Species Description

1. Morphology and Chemistry

L. linita is a medium to large foliose lichen, green to greenish-brown or brownish, and becoming bright green when wet. It is distinguished from other *Lobaria* species by its green alga and lack of isidia, soredia, and lobules (**Figure 18**). Two different morphotypes are recognized as varieties: *L. linita* var. *linita* tends to be small, reticulately wrinkled and sterile; *L. linita* var. *tenuior* is larger, reticulately ribbed, and usually fertile (Jordan 1973). This species may be confused with *L. pulmonaria*, which has soredia.

Technical Description: Thallus to 15 cm broad, loosely attached, coriaceous-membranaceous, reticulately rugose or ribbed; green to brown, greener when wet. Lobes broad and rounded, rarely linear, up to 4 x 6 cm; tips often ascending, more or less shiny, typically darker than rest of thallus. Margins crenate to truncate-crenate, sinus often thickened. Lobules, soredia, and isidia absent. Ventral surface with light-colored naked swellings, separated by smooth, rarely corrugate, tomentose veins, often blackened. Tomentum light-colored when young, usually lacking from marginal zone; rhizines in older portions, dark-colored, up to 4 mm long. Alga green; cephalodia of cyanobacteria internal, numerous, appearing on both surfaces as hemispherical or globose swellings up to 2.0 mm broad, with dark area at pole. Pycnidia absent or abundant, on dorsal surface and sometimes margins as slight swellings. Apothecia absent in *L. linita* var. *linita*, common in *L. linita* var. *tenuior*, lamellar and marginal, scattered, 1-4 mm broad, flat and becoming strongly convex. Thallus K-, C-, KC-, PD- (Jordan 1973). Tenuorin, methyl evernate, methyl gyrophorate, and other substances present (McCune and Goward 1995).

2. Reproductive Biology

The two varieties of *L. linita* apparently have different reproductive strategies. Thalli of *L. linita* var. *tenuior* are typically apotheciate, and reproduction is presumably by spores (Jordan 1973); *L. linita* var. *linita* is reported as sterile.

3. Ecological Roles

L. linita is a nitrogen-fixing lichen. Nitrogen-fixing lichen species play an important ecological role by contributing nitrogen to ecosystems. Nitrogen-fixing lichens can contribute up to 25% of the total nitrogen in some forest ecosystems (Pike 1978). *L. linita* is not as abundant or widespread as the other two common *Lobaria* species in the Pacific Northwest, *L. oregana* and *L. pulmonaria*. Although *L. linita* is generally restricted in its ecological distribution and not abundant when present, it may be the only nitrogen-fixing species— or one of a few species— in the habitats where it occurs and thus provides a source of nitrogen in ecosystems where this nutrient is often limiting.

C. Range and Known Sites

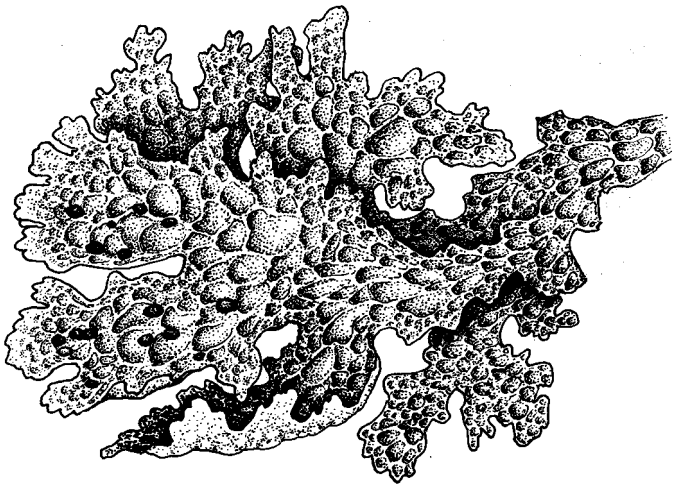

Figure 18. Drawing of *Lobaria linita.*

L. linita has an incomplete circumboreal range and is found in the European Alps, Norway, Siberia, eastern Asia, and North America. In North America, *L. linita* is found as far north as the Alaskan and Canadian Arctic, and south to British Columbia and Washington; it is uncommon in the northern Rocky Mountains and reported from Oregon and California. The southern limit of the species is currently unknown.

L. linita has been documented from more than 50 sites in the range of the northern spotted owl. Most of the known sites are in northwestern Washington. *L. linita* is known from Clallam, Jefferson, Grays Harbor, Whatcom, Skagit, Snohomish, King, and Lewis Counties in Washington, and is reported from Chelan and Yakima Counties on the eastern slope of the Washington Cascades. The reported sites from Oregon (Polk and Clackamas Counties) and California (Humboldt County) need to be verified. Current information available from known site collections does not distinguish between the two varieties; however, if that information becomes important, voucher specimens can be reexamined to determine varietal status.

In the Pacific Northwest, *L. linita* is most common in northwestern Washington, and most of the known sites are on the Mt. Baker-Snoqualmie NF. This species is found in the Nooksack River valley and Mt. Baker area, Baker Lake basin, Finney Block, Sauk Mountain area, Cascade River, Glacier Peak Wilderness, White Chuck area, Boulder River Wilderness, Mt. Pilchuck, Stillaguamish watershed, Mt. Persis, Beckler Peak, Martin Creek in the Tye watershed, Alpine Lakes Wilderness, and the Middle Fork Snoqualmie River. It is documented from Easy Creek near the Cascade crest on the Okanogan NF and on the Olympic Peninsula in the Olympic NF and Olympic National Park. On the Olympic Peninsula, it is known in the northeastern Olympics, Pine Mountain, Matheny Ridge, and Colonel Bob Wilderness. It is reported from Lewis County on a rocky ridgetop.

L. linita is documented from three sites east of the Cascade crest in Washington on the Wenatchee NF. On the Lake Wenatchee Ranger District, it occurs in the Nason Creek watershed just east of Stevens Pass near Big Chief Mountain, and in Whitepine Creek. It is also reported from the Naches Ranger District near Crow Creek in the Little Naches watershed.

In Oregon, collections are reported from Salem District BLM Little Sink Research Natural Area (RNA)/Area of Critical Environmental Concern (ACEC); however, this population is of doubtful existence. Several trips to the Little Sink area to relocate this lichen have found only *L. pulmonaria* (a species similar in morphology) and not *L. linita*. Previous collections from this site may have been misidentified. The other Oregon location of *L. linita*, in Bull of the Woods Wilderness on the Mt. Hood NF (Sillett, pers. comm.), although an outlier geographically, appears to fit the current ecological concept for the lichen. Two sites are reported from Humboldt County in California. Based on current information, the populations reported from Oregon and California are outliers geographically and ecologically, and need to be verified. Two records from the Marble Mountains Wilderness on the Klamath NF in California were previously misidentified as *L. linita*.

D. Habitat Characteristics and Species Abundance

Two varieties of *L. linita* are recognized based on habitat characteristics and presence of apothecia; they also have different ecological distributions. *L. linita* var. *linita* is a sterile variety that grows over rock, mossy hummocks and soil in arctic and alpine moss/heath communities; *L. linita* var. *tenuior* is typically apotheciate, and occurs on the lower boles, trunks, and branches of conifers and deciduous trees and shrubs in montane temperate coniferous forests (Jordan 1973). We presume that the variety of concern under the Northwest Forest Plan is the one typically associated with old-growth forest habitats, *L. linita* var. *tenuior*.

Most (85%) known sites of *L. linita* in the range of the northern spotted owl are in northwestern Washington in the North Cascades and Olympic Mountains. *L. linita* is not common in this area however, nor is it abundant where it occurs. This species is restricted in its ecological distribution, and typically only a few individuals are observed at a site. It appears there are factors that limit the dispersal and establishment of this lichen, as it is often absent from sites that appear to be suitable habitat. When present, *L. linita* typically has a patchy distribution within the stand, and is absent on apparently suitable substrate. *L. linita* is very limited in distribution and appears to be restricted primarily to old-growth and climax forests.

The typical habitat for *L. linita* in northwestern Washington is old-growth to climax forests in the Pacific Silver Fir (*Abies amabilis*) Zone and occasionally the lower Mountain Hemlock (*Tsuga mertensiana*) Zone, in mesic to moist Alaska Huckleberry (*Vaccinium alaskaense*) plant associations. It generally grows on the lower boles of conifers, especially Pacific silver fir. Its elevational range is generally between 700-1100 m (2295-3610 ft), although it may be found at lower elevations in areas of high precipitation or in sites with cold air drainage.

Less commonly, *L. linita* may grow on moss-covered rock substrates, in cool, shaded, humid microsites. It may be found in these types of sites in drier habitats or at higher elevations, or in areas of cold air drainage. It has also rarely been found on moss-covered boulders in vine maple/Sitka alder communities on talus slopes in the North Cascades.

Atypical habitats include the Sulphur Creek Lava Flow, where it is in an open forest as an epiphyte on subalpine fir (*Abies lasiocarpa*) or shrubs, and in the Douglas-fir/Oceanspray-Baldhip Rose (*Pseudotsuga menziesii*/*Holodiscus discolor-Rosa gymnocarpa*) plant association in the rainshadow area of the northeastern Olympics.

L. linita is considered to be closely associated with old-growth forests in the Pacific Northwest. In northwestern Washington, it is typically found in forests that are old-growth to climax in age and forest structure. Of the ecology plots where *L. linita* has been documented on the Mt. Baker-Snoqualmie and Olympic NFs, more than 80% were in stands older than 200 years, with more than half of these plots in stands ranging in age from 400 to more than 1000 years (Mt. Baker-Snoqualmie NF Ecology Program data files).

A few records come from higher elevation, non-forest sites in the Olympics and North Cascades, but they probably are *L. linita* var. *linita*. The species has been reported from subalpine sites up to 2040 m elevation (6700 ft). One record reports the species on moss in a subalpine dwarf shrub community dominated by heather (*Phyllodoce empetriformis* and *Cassiope mertensiana*). In Lewis County, the species has been reported from rocky ridgetops. Just east of the Cascade crest near Big Chief Mountain, it occurred in an open mountain hemlock/big huckleberry (*Vaccinium membranaceum*) community, on a moss-covered rock near the ridgetop at 1770 m (5800 ft) elevation. Again, these collections are probably *L. linita* var. *linita*.

Elsewhere on the Wenatchee NF, *L. linita* was documented in habitats that are similar to those found west of the Cascade crest. At these two sites, it occurred in forests bordering the Western Hemlock and lower Pacific Silver Fir Zones, in cool, moist sites on moss covered rocks.

Habitat information is sketchy for the reported sites in Oregon and California, and there are questions regarding their validity as known sites for *L. linita*. The site in Oregon at Little Sink RNA/ACEC (which has been revisited but not verified) is described as a mature Douglas-fir forest, with old-growth structural components, at 165 m (540 ft) and 245 m (805 ft) elevation. Associated species include red alder (*Alnus rubra*), bigleaf maple (*Acer macrophyllum*), and salal *(Gaultheria shallon*). "*L. linita*" was found in the litterfall. It has not been reported from litterfall from any of the other known sites. The other Oregon site in Bull of the Woods Wilderness was on a mossy boulder in an old-growth forest in the transition area between the Western Hemlock Zone and Pacific Silver Fir Zone, elevation 914 m (3000 ft). This habitat information is consistent with other known sites in northwestern Washington, and is considered a valid site. Only general habitat information is available for the Humboldt County sites in California, where the habitat was described as an oak forest with rock outcrops, and a late-mature tanoak (*Lithocarpus densiflorus*) and madrone (*Arbutus menziesii*) forest.

II. CURRENT SPECIES SITUATION

A. Why Species is Listed Under the Survey and Manage Standard and Guideline

L. linita was considered at risk under the Northwest Forest Plan because of its rarity and limited distribution in the range of the northern spotted owl (USDA and USDI 1994a, 1994b). At the time of the lichen viability panel, it had been reported from 10 sites in Washington and one in Oregon (USDA and USDI 1994b). Viability concerns were also noted for this species because of its presumed sensitivity to air pollution as inferred from the known sensitivity of other nitrogen-fixing lichen species. However, the pollution sensitivity of *L. linita* is not known.

Concerns for species persistence under the Northwest Forest Plan ranges from moderate in northwestern Washington, to high in Oregon and California. Only two populations of *L. linita* are reported from Oregon and two from California; all four are isolated. Whether these populations still exist is uncertain, as is whether they are correctly identified as *L. linita*. If air quality deteriorates significantly in the future, and *L. linita* is shown to be sensitive to air pollution, then concerns for species persistence would be high throughout most of its range. *L. linita* was listed under the Survey and Manage Standard and Guideline to manage known sites, to locate additional populations on federal lands, and to identify high priority sites for management (USDA and USDI 1994c).

B. Major Habitat and Viability Considerations

The major viability considerations for *L. linita* are loss of populations from management activities that affect the populations or their habitat, or declines in viability resulting from air pollution. The distribution of this species along the western front of the North Cascades makes it potentially vulnerable to air pollution effects. A warming climate may stress populations at the limits of a species' range and could result in a decline in vigor and a more restricted distribution of *L. linita.*

It appears there are factors that limit the dispersal and establishment of this lichen. *L. linita* is often absent from sites that appear to be suitable habitat. Even when this species occurs, it is patchy in its distribution and is absent on apparently suitable substrate.

C. Threats to the Species

Threats to *L. linita* are those actions that disrupt stand conditions necessary for its survival. This includes treatments that may affect populations, such as removal of colonized substrates, stand treatments that change micro-climatic conditions, and disturb forest structure. A significant deterioration in air quality is a potential threat.

D. Distribution Relative to Land Allocations

The distribution of known sites of *L. linita* relative to land allocations needs to be determined. Each administrative unit should evaluate the land allocations for known sites on lands within its jurisdiction, and share this information at the regional level.

III. MANAGEMENT GOAL AND OBJECTIVES

A. Management Goal for the Species

The goal for managing *L. linita* is to assist in maintaining species viability.

B. Objectives

Manage all known sites on federal lands by maintaining habitat, forest structure, occupied and potential suitable substrate, and micro-climatic conditions associated with *L. linita*.

IV. HABITAT MANAGEMENT

A. Lessons From History

L. linita is considered a species closely associated with old-growth forests in the Pacific Northwest. In northwestern Washington, it is typically found in forests that are old-growth to climax in age and forest structure. Only 2 ecology plots on the Mt. Baker-Snoqualmie and Olympic NFs document *L. linita* in young stands— aged at 37 and 55 years; both populations had persisted from the previous stands. The occurrence of *L. linita* on a cut stump in the 37-year-old stand suggests that the thallus persisted after a clear-cut harvest and patchy burn. This stand was revisited in September 1998, and the lichen was not relocated after an extensive search. The other ecology plot documented *L. linita* in a young stand that was clear-cut and burned, although the burn was patchy. Here the lichen was on a rock outcrop on a steep, north-facing slope in the moist Pacific Silver Fir/Alaska Huckleberry-Foamflower (*Tiarella unifoliata*) plant association. The shrub cover was dense, and probably recovered soon after the treatments. The dense shrub cover, cool moist microclimate, and the landscape context of the population probably contributed to the ability of the lichen thalli to survive harvest and burn treatments at this site. Given the predominance of *L. linita* populations in old-growth to very old stands and the limited sightings of *L. linita* in young stands in plant associations where *L. linita* does occur, the survival of *L. linita* after a clear-cut and burn treatment is apparently not typical.

Lichen species with specific ecological requirements may experience population declines in response to land management activities that affect habitat or decrease potential or occupied habitats. Loss of lichen species richness has been documented in areas of Europe in response to land management practices (Rose 1988, Olsen and Gauslaa 1991, Esseen *et al*. 1992). The close association of *L. linita* with old-growth forests in the Pacific Northwest is an indication of specific ecological requirements, and may reflect the inability of this species to become established or maintain viable populations in younger forests.

Many lichen species are known to be sensitive to air pollution, and lichen population declines attributed to air pollution have been documented in Europe and North America (Rao and LeBlanc 1967, Skye and

Hallberg 1969, Hawksworth 1971, Ferry et al. 1973, Hawksworth and Rose 1976, Case 1980, Sigal and Nash 1983, Gilbert 1992). Many nitrogen-fixing lichen species are especially sensitive to air pollution, particularly sulfur dioxide (Wetmore 1983). The sensitivity to air pollution of the nitrogen-fixing species *L. linita* needs to be determined. Based on the known sensitivity of other nitrogen-fixing lichens, however, *L. linita* is likely to be affected by air pollution.

The decline of lichens in Europe has resulted in the development of lists of threatened species. Sweden has a "red list" of lichens threatened with extinction because of air pollution and habitat degradation (Thor 1990). Three species of *Lobaria* are listed as endangered on this list (Databanken for hotade arter och Naturvardsverket 1991). The International Association of Lichenology has recently initiated a listing of lichens threatened globally.

B. Identifying Habitat Areas for Management

All known sites of *L. linita* on federal land administered by the Forest Service and BLM within the range of the northern spotted owl are identified as habitat areas where these management recommendations apply. A habitat area for management is defined as suitable habitat occupied by or adjacent to a known population.

C. Managing In Habitat Areas

- Determine the extent of the local population and habitat area with a field visit.
- Habitat areas should be managed to include an area large enough to maintain the ecological conditions associated with *L. linita*, including undisturbed forest structure and interior forest micro-climatic conditions.
- At all locations, current habitat conditions should be maintained, and allowed to develop naturally. The size of the area necessary to maintain populations and interior forest conditions should be determined by a field visit.
- Maintain occupied substrate and provide for a distribution of appropriate substrate in habitat areas.
- Restrict thinning or other stand treatments that will alter stand microclimate.
- Prevent fire in habitat areas with emphasis on fire suppression.
- Restrict collection of specimens in areas where this species is rare or of limited abundance.

The majority of known sites in the range of the northern spotted owl are on the Mt. Baker-Snoqualmie and Olympic NFs. The current management direction for these two Forests under the Northwest Forest Plan allocates a majority of the land base to reserve status, and therefore very little of the landscape is available for management treatments that may affect this species.

L. linita is restricted in its ecological distribution, and typically only a few individuals are observed at a site. However, in a few areas on the Mt. Baker-Snoqualmie NF, it may be more prevalent. In these areas, if a population of *L. linita* is in a project area, evaluate several factors to determine the importance of the population in relation to other known sites, and the contribution of that population to the species' persistence. Consider the landscape and ecological context of the population— e.g., factors such as the location of the population relative to other known populations, its relative isolation, the ecological conditions of the site and how they compare to other known sites (typical or atypical), the areal extent of the population and the abundance of the lichen in the local population, and the availability of suitable habitat in the area. Each local population should be maintained intact, however, it may be acceptable to impact a small percentage of known individuals at a particular site if it has only minimal impact to the persistence of the local population. Special consideration should be given to maintaining populations near the edge of the geographical range of *L. linita*, in watersheds where it is rare and of limited distribution, or in sites that represent the limits of its ecological amplitude.

D. Other Management Issues and Considerations

- In the range of *L. linita* where old forests are limited in extent, target the older stands in watersheds to meet the Standard and Guideline for 15% retention of old-growth in watersheds where little remains. Maintaining the older age classes across the landscape is important for *L. linita* as this lichen typically does not occur in younger late-successional forests.
- Providing a well-distributed network of older forests in the range of *L. linita* will provide stands to replace those lost to fire, blowdown, or other natural disturbance events.
- *L. linita* should be evaluated for its sensitivity to air pollutants. As a nitrogen-fixing lichen, it is thought to be very sensitive to air pollutants.

V. RESEARCH, INVENTORY, AND MONITORING NEEDS

The objective of this section is to identify opportunities to acquire additional information which could contribute to more effective species management. The content of this section has not been prioritized or reviewed as to how important the particular items are for species management. The inventory, research, and monitoring identified below are not required. These recommendations should be addressed by a regional coordinating staff.

A. Data Gaps and Information Needs

- Revisit known sites to verify the status of reported or known populations, determine the extent of the populations and abundance, and characterize ecological conditions.
- Determine the distribution of *L. linita* in areas identified as potential suitable habitat. Assign priority for Strategy 3 surveys in areas where projects are scheduled or proposed.
- Determine the status of the populations of *L. linita* in the two young stands on the Mt. Baker-Snoqualmie NF.
- Determine the southern extent and eastern limit of *L. linita* in the area covered by the Northwest Forest Plan.
- Verify the Salem District BLM Little Sink ACEC population to determine if *L. linita* is present there, or if the specimens were misidentified, and are actually *L. pulmonaria.*
- Verify the California populations in Humboldt County to determine if they are indeed *L. linita*.
- Determine the ecological distribution of the two varieties of *L. linita*. If *L. linita* var. *linita* is documented as a lichen of non-forest habitats, then specify management recommendations for the lichen *L. linita* var. *tenuior*.
- Determine the air pollution sensitivity of *L. linita*

B. Research Questions

- What habitat characteristics and ecological conditions are necessary for establishment of *L. linita* propagules and survival of established thalli?
- Is *L. linita* sensitive to air pollution?
- What are the dispersal mechanisms and dispersal distances of *L. linita*?
- What limits dispersal and establishment of propagules and colonization of suitable habitat?
- What are the rates of growth and reproduction for *L. linita*?
- What is the genetic diversity of this species within its local populations and across the region?

C. Monitoring Needs and Recommendations

- Establish monitoring plots in the two young stands on the Mt. Baker-Snoqualmie NF to document population trends of *L. linita* during stand development.

- If management activities occur near known sites, monitor the population to determine its response to treatment and effects on the population.
- Consider establishing air quality monitoring plots near selected known populations.

Lobaria linita

Loxosporopsis corallifera

SUMMARY

Species: *Loxosporopsis corallifera* Brodo, Henssen & Imshaug
[formerly *Loxospora* sp. nov. "*corallifera*"]
Taxonomic Group: Lichens (Oceanic-Influenced)
ROD Components: 1, 3

Other Management Status: None

Range: *Loxosporopsis corallifera* is a North American endemic ranging from southeastern Alaska and the Queen Charlotte Islands south to the coast of northern California. It may be locally common in the range of the northern spotted owl, specifically in the Oregon Coast Range and along the central Oregon Coast. This species is documented from at least 30 sites within the range of the northern spotted owl. Ownership for all known sites is currently not available, but at least 22 are on federal land.

Specific Habitat: In the range of the northern spotted owl, *L. corallifera* may be found in several different types of habitats, where it is generally an epiphyte on conifers. It occurs near sea level in the coastal dune/wetland mosaic, often with dense shrubs and in open stands of shore pine, Sitka spruce, and Douglas-fir. It is also found in upland conifer and riparian forests of the western Hemlock and lower Pacific Silver Fir zones up to 1210 m (4000 ft) elevation in the Oregon Coast Range and up to 790 m (2600 ft) in the Cascades, and has been reported on an alder snag in a sphagnum bog. The species has been documented in open to dense stands in young forests (50-70 years), and in mature and old-growth stands.

Threats: The major threat to *L. corallifera* is loss of populations due to activities that affect the populations or their habitat, particularly removing colonized substrate.

Management Recommendations:

- Manage populations at known sites by maintaining the ecological conditions associated with *L. corallifera*, including forest structure, substrate, and microclimate.
- Maintain habitat conditions at the type locality of *L. corallifera* at Sutton Creek and avoid disturbing this site once the precise location is determined.

Information Needs:

- Determine if *L. corallifera* meets the criteria established for designating a species as closely associated with late-successional or old-growth forests.
- Determine the distribution of populations, species abundance, and ecological requirements of *L. corallifera* in the range of the northern spotted owl.
- Determine the precise location of the type locality of *L. corallifera* at Sutton Creek.

Loxosporopsis corallifera

I. NATURAL HISTORY

A. Taxonomy and Nomenclature

Loxosporopsis corallifera Brodo, Henssen & Imshaug was described in 1995 (Brodo and Henssen 1995). It was formerly referred to as *Loxospora* sp. nov. "*corallifera*" (Brodo in edit, USDA and USDI 1994a). Although it bears many similarities to the genus *Loxospora*, its developmental anatomy and chemistry make it distinct (Brodo and Henssen 1995).

B. Species Description

1. Morphology and Chemistry

L. corallifera is an inconspicuous, small white isidiate crustose lichen that is easily overlooked (**Figure 19**). When well developed, it can easily be mistaken for young *Sphaerophorous globosus*, with the isidia resembling young podetia. The absence of a white crust and the typically orange or greenish color of *S. globosus* help distinguish the two species.

Technical description: Thallus crustose, clearly visible and mostly continuous, more or less smooth or rimose, pale, yellowish-white or light brown to pale orange, more or less covered with very long, slender, cylindrical isidia, unbranched or branched, 0.5-2.4 mm long, 0.07-1.5 mm in diameter; soredia absent. Photobiont a green alga, *Trebouxia*. Apothecia lecanorine, 0.5-0.8 (1) mm in diameter, occurring singly, sessile or constricted at the base, flat when mature, smooth. Thalli with apothecia are rarely found outside of the Queen Charlotte Islands. Pycnidia very rare. All spot tests negative; thallus cortex UV (LW)+ white or bluish-white (Brodo and Henssen 1995).

2. Reproductive Biology

L. corallifera reproduces sexually by producing ascospores in apothecia. Apothecia were documented in the North Cascades population, but material with ascocarps is rare in the range of the northern spotted owl. Vegetative reproduction by isidia is probably the main mode of reproduction for *L. corallifera* in this region.

3. Ecological Roles

Little is known about the ecological roles of *L. corallifera*.

C. Range and Known Sites

L. corallifera is a North American endemic ranging from southeastern Alaska and the Queen Charlotte Islands south to the coast of northern California. It may be locally common in the range of the northern spotted owl, particularly in the Oregon Coast Range and along the central Oregon Coast. The type locality is on the Siuslaw NF at Sutton Creek Forest Camp on the Oregon Coast (Brodo and Henssen 1995). Most known sites are in the Oregon Coast Range or along the Oregon Coast. It is known from at least 30 sites in the range of the northern spotted owl; ownership for all known sites is currently not available, but at least 22 are on federal land. Known sites on federal lands in Oregon are on the Mt. Hood and Siuslaw NFs, Columbia River Gorge National Scenic Area, Oregon Dunes National Recreation Area and BLM lands; Washington sites are on the Gifford Pinchot, Olympic, and Mt. Baker-Snoqualmie NFs, and in Olympic National Park.

In Oregon, *L. corallifera* is known from Mary's Peak, McDonald Forest, and Salem District BLM Grass Mountain Area of Critical Environmental Concern (ACEC) (Benton Co.); Elk Creek area within 2-4 km (1-3 mi) of the Pacific Ocean (Coos County); Sutton Creek, Siltcoos River Area, Eugene District BLM Heceta Dunes ACEC, Oregon Dunes National Recreation Area (NRA), Lake Creek Falls and watershed, and Mohawk Research Natural Area (RNA) (Lane and Douglas Counties); Death Ridge, Canal Creek, and Lost Prairie ACEC (Lincoln County); near Camp Meriweather and Hebo Ranger District (Tillamook and Yamhill Counties); Old Maid Flats and Zigzag Ranger District (Clackamas County); near Lookout Point in the Bull Run Watershed, and McCord Creek in the Columbia River Gorge (Multnomah County).

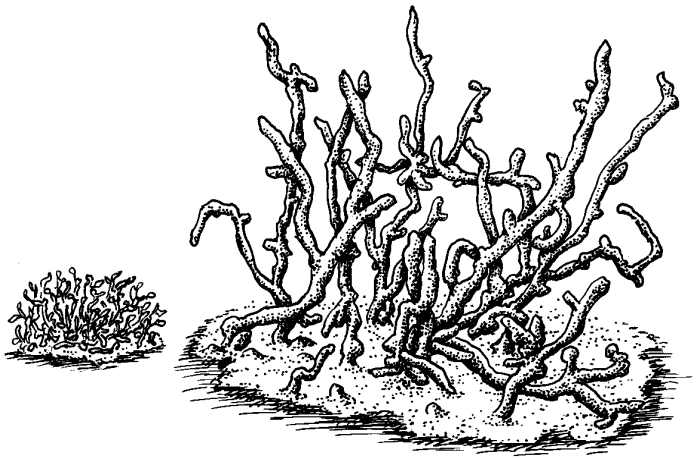

Figure 19. Drawing of *Loxosporopsis corallifera.*

The known sites of *L. corallifera* in Washington are more disjunct, perhaps an artifact of survey intensity, or this species may not be as widespread or common as in Oregon. It is known from the Washington Cascades near Goat Marsh RNA on the Gifford Pinchot NF (Cowlitz County), and the Suiattle River lahar on the Mt. Baker-Snoqualmie NF (Snohomish County). On the Olympic Peninsula, it is reported from Hurricane Ridge in Olympic National Park (Clallam County), the Hoh River (Jefferson County, unknown ownership), and the Dennie Ahl area on the Olympic NF (Mason County).

In California, it is known from the Lanphere Dunes Unit (Humboldt Bay National Wildlife Refuge, USFWS) (Humboldt County) (Brodo and Henssen 1995).

D. Habitat Characteristics and Species Abundance

L. corallifera may be locally common in the range of the northern spotted owl. It grows as an epiphyte on conifers, including lodgepole (shore) pine (*Pinus contorta*), Douglas-fir (*Pseudotsuga menziesii*), western hemlock (*Tsuga heterophylla*), noble fir (*Abies procera*), Sitka spruce (*Picea sitchensis*), and on evergreen huckleberry (*Vaccinium ovatum*), snags, and stumps. It appears to have a broader ecological amplitude in the range of the northern spotted owl than was previously thought.

L. corallifera has been documented in several different habitats in the Sitka Spruce, Western Hemlock, and lower Pacific Silver Fir zones. The known elevation range for this species is from near sea level to 1210 m (4000 ft) in the Oregon Coast Range, and up to 790 m (2600 ft) in the Cascades. It grows near sea level in the coastal dune-wetland mosaic, with dense shrubs and in open stands of shore pine, Sitka spruce, and Douglas-fir, and in shore pine and *Arctostaphylos* sand dunes near the Pacific Ocean. Upland habitats include western hemlock/Douglas-fir forests ranging from young closed-canopy forests to mature and old-growth stands in the Cascades and Oregon Coast Range, and in upper elevation noble fir forests in the Oregon Coast Range. In the North Cascades, it was found in a 70-year-old forest in the Western Hemlock/Salal (*Gaultheria shallon*) plant association dominated by lodgepole pine, Douglas-fir, and salal. Near Goat Marsh RNA, it was in a forest dominated by lodgepole pine with scattered Douglas-fir, western hemlock and western white pine (*Pinus monticola*), with understory of kinnikinnick (*Arctostaphylos uva-ursi*) and *Racomitrium*. On the Olympic NF in the Dennie Ahl area, *L. corallifera* was documented in a young stand in the Western Hemlock/Salal-Beargrass (*Xerophyllum tenax*) plant association. Parent material consists of mudflow, lahar, or pyroclastic deposits at Old Maid Flats, the Suiattle River, and Goat Marsh RNA sites.

L. corallifera has also been documented in riparian or wetland habitats in the Oregon Cascades and Coast Ranges. Habitats include a valley bottom, riparian old-growth stand of Douglas-fir with red alder (*Alnus rubra*) and bigleaf maple *(Acer macrophyllum*); an old-growth Douglas-fir/western hemlock forest with inclusions of sedge-Oregon ash-red alder (*Carex-Fraxinus latifolia-Alnus rubra*) wetlands; and as an epiphyte on an alder snag in a sphagnum bog.

In the Queen Charlotte Islands of British Columbia, it is particularly abundant on the bark of coniferous trees in exposed bogs and swamps (Brodo and Henssen 1995).

II. CURRENT SPECIES SITUATION

A. Why Species Is Listed Under Survey and Manage Standard and Guideline

L. corallifera was considered at risk under the Northwest Forest Plan because of its presumed rarity and limited distribution in the range of the northern spotted owl. Information available at the time of the viability rating suggested this species was restricted to old-growth stands in the coastal fog zone (USDA and USDI 1994a, 1994b).

The concern for species persistence under the Northwest Forest Plan varies from low in the Oregon Coast Range, where this species is fairly common, to moderate in the Oregon Cascades and Washington, where known populations are fewer and more isolated, based on current information. *L. corallifera* is listed as a Survey and Manage Strategy 1 and 3 species with objectives to manage known sites and to conduct surveys to identify high priority sites for management (USDA and USDI 1994c).

B. Major Habitat and Viability Considerations

The major viability consideration for *L. corallifera* is loss of populations resulting from management activities that affect the populations or their habitat. A warming climate may stress populations at the limits of the species' range, and may result in a decline in vigor and a more restricted distribution of *L. corallifera*.

The occurrence of *L. corallifera* in different types of habitats, and in young and mature stands suggests that it may have a fairly broad ecological amplitude, and may not be as restricted in habitat or distribution as was thought at the time of the viability rating (USDA and USDI 1994a, 1994b). Information available since the FEMAT rating also suggests this species is more common in this region than was previously thought.

C. Threats to the Species

Threats to *L. corallifera* are those actions that disrupt stand conditions necessary for its survival, particularly removing colonized substrate. The sensitivity of this species to air pollution is not known.

D. Distribution Relative to Land Allocations

The distribution of known sites of *L. corallifera* relative to land allocations needs to be determined. Each administrative unit should evaluate the land allocations for known sites on lands within its jurisdiction, and share this information at the regional level.

III. MANAGEMENT GOAL AND OBJECTIVES

A. Management Goal for the Species

The goal for managing *L. corallifera* is to assist in maintaining species viability.

B. Objectives

Manage known sites on federal lands by maintaining habitat, forest structure, occupied and potential suitable substrate, and micro-climatic conditions associated with *L. corallifera*.

IV. HABITAT MANAGEMENT

A. Lessons From History

No specific information is available at this time.

B. Identifying Habitat Areas for Management

Known sites of *L. corallifera* on federal lands administered by the Forest Service and BLM in the range of the northern spotted owl are identified as areas where these management recommendations apply. A habitat area for management is defined as suitable habitat occupied by or adjacent to a known population.

C. Managing in Habitat Areas

- Determine the extent of the local population and habitat area with a field visit.
- Manage habitat areas to include an area large enough to maintain the habitat and associated microclimate of the population.
- Maintain colonized substrates and provide for a distribution of appropriate substrate within the habitat area.
- Restrict collecting specimens where the species is rare or of limited abundance.
- Manage the site of the type locality to maintain the habitat conditions for *L. corallifera*. Determine the precise location of the type locality at Sutton Creek, identify and mitigate potential threats to the persistence of this population, and avoid disturbing the site.
- Maintain each local population of *L. corallifera* in watersheds where it is rare or of limited distribution.
- In watersheds where *L. corallifera* is more widespread or locally common, particularly along the Oregon Coast, or in the Oregon Coast Range, maintain enough individuals in a project area to sustain the local population. Before impacting a population, evaluate several factors to determine the importance of the population relative to other known sites, and the contribution of the population to the persistence of the species. Consider the landscape and ecological context of the population, and factors such as the location of the population in relation to other known sites, the relative isolation of the population, the ecological conditions of the site and how they compare to other known sites (typical or atypical), the areal extent of population and the species abundance, and the availability of potential suitable habitat in the area. Each local population should be maintained, however, it may be acceptable to impact a small percentage of individuals at a particular site if it has minimal impact to the persistence of the local population.

D. Other Management Issues and Considerations

Information from reported sites suggests that *L. corallifera* may not be closely associated with late-successional or old-growth forests. For a species to be appropriately listed as a Survey and Manage species, it must first meet the criteria established for designation as a species closely associated with late-successional or old-growth forests (USDA and USDI 1994a [Table IV-6] and 1994b). This issue should be addressed by a regional coordinating staff.

V. RESEARCH, INVENTORY, AND MONITORING NEEDS

The objective of this section is to identify opportunities to acquire additional information that could contribute to more effective species management. The content of this section has not been prioritized or reviewed as to how important the particular items are for species management. The inventory, research, and monitoring identified below are not required. These recommendations should be addressed by a regional coordinating staff.

A. Data Gaps and Information Needs

- Determine if *L. corallifera* is closely associated with late-successional or old-growth forests.
- Determine the precise location of the type locality of *L. corallifera* at Sutton Creek.
- Revisit known sites to verify the status of known populations, determine the extent of populations and abundance, and characterize ecological conditions.
- Determine the distribution of populations, species abundance, and ecological requirements of *L. corallifera* in the range of the northern spotted owl.

B. Research Questions

- How does *L. corallifera* respond to forest clearing activities (thinning, harvesting, and road building), particularly changes in light, temperature and moisture regimes?
- What are the dispersal mechanisms and dispersal distances of this species?
- Which habitat characteristics and ecological conditions are necessary for establishment of *L. corallifera* propagules and survival of established thalli?
- What limits dispersal and establishment of propagules and colonization of suitable habitat?
- What are the minimum and optimum patch sizes of colonized habitat necessary to provide for this species after timber harvest and thinning?
- How should refugial patches be distributed across the landscape to optimize recolonization into managed stands?
- Is *L. corallifera* sensitive to air pollution?
- What is the genetic diversity of this species within its local populations and across the region?

C. Monitoring Needs and Recommendations

If management treatments occur near known sites, monitor populations to determine the response to treatment and effects on the local population.

Niebla cephalota

SUMMARY

Species: *Niebla cephalota* (Tuck.) Rundel & Bowler
Taxonomic Group: Lichens (Rare Oceanic-influenced)
ROD Components: 1, 3

Other Management Status: Oregon Natural Heritage Program List 3 (more information is needed before status can be determined, but may be threatened or endangered in Oregon or throughout range). Natural Heritage Networks Rank Global Rank G4 (not rare and apparently secure, but with cause for long-term concern, usually with more than 100 occurrences). State Rank S2 (imperiled because of rarity or because other factors demonstrably make it very vulnerable to extirpation, typically with 6-20 occurrences) (Oregon Natural Heritage Program 1998). BLM Tracking Status (USDI Bureau of Land Management 1998).

Range: *Niebla cephalota* is a North American coastal endemic, ranging from Baja California to Washington. In Washington, it is known from three locations: Roche Harbor, San Juan Island; Deception Pass State Park; and Northwest Fidalgo Island. In Oregon, is known from four locations: Sutton Creek Recreation Area and Spinreel Campground, Siuslaw NF; Cape Blanco State Park; and Cape Arago State Park. In California, it is known from two locations: the Samoa Peninsula and Patricks Point State Park. Only three locations are on federal land.

Specific Habitat: In the range of the northern spotted owl, *N. cephalota* has been found on exposed Sitka spruce, Hooker's willow, Monterey cypress, and shore pine in open forests, forest edges, and scrublands along windswept coastal headlands, sand dunes, stabilized deflation plains, and marshy swales of the immediate coast.

Threats: The main threats are activities that directly harm the populations, their habitat, or the suitable habitat surrounding populations. Examples of threats include: burning (in some places); harvesting trees; constructing roads, trails or buildings; recreational activities; grazing; invasive exotic plants; changes in local hydrology; and air pollution.

Management Recommendations:

- Manage known sites to maintain local populations and their habitat areas.
- Develop practices to route human use away from known sites.
- Manage fire in habitat areas, with emphasis on prevention near occupied substrates.
- Restrict removal of trees, shrubs, or other vegetation from the known sites and habitat areas, except when removal will not harm habitat integrity.

Information Needs:

- Visit known sites to describe the geographical extent of local populations, improve habitat descriptions.
- Determine if this species is closely associated with late-successional or old-growth forests.
- Determine if additional populations exist in areas identified as potential suitable habitat.

I. NATURAL HISTORY

A. Taxonomy and Nomenclature

N. cephalota (Tuck.) Rundel & Bowler

Basionym:
Ramalina ceruchis (Ach.) De Not. f. *cephalota* Tuck.
Synonyms:
Ramalina cephalota Tuck.
Desmazieria cephalota (Tuck.) Follmann & Huneck
Vermilcinia cephalota (Tuck.) Spjut & Hale

N. cephalota is a lichenized fungus in the family Ramalinaceae, order Lecanorales, class Ascomycetes (Tehler 1996). Within *Niebla*, *N. cephalota* is part of the "ceruchoid" group, species with a terpenoid chemistry and lacking well-developed chondroid strands (Bowler et al. 1994). *Niebla* is the Spanish word for "fog" or "mist", a suitable epithet for the habitat of this species.

N. cephalota was first recognized as a taxonomic entity in 1882 by Tuckerman, who considered it a form of *Ramalina ceruchis*. Tuckerman himself later raised this lichen to the species level. In 1968, Follmann and Huneck transferred *Ramalina cephalota* to the genus *Desmazieria* Mont. But, the lichen genus *Desmazieria* Mont. was abandoned after Rundel and Bowler (1978) successfully argued that it was a homonym for the earlier legume genus, *Desmazeria* Dumortier. Because both were created in honor of the French botanist, J.B.H.J. Desmazières, the International Code of Botanical Nomenclature dictated that *Desmazieria* Mont., the later homonym, was invalid. To replace it, Rundel and Bowler created *Niebla*. Some members of *Desmazieria* were assigned to *Niebla*, the rest to *Ramalina.* *Niebla* is distinguished from *Ramalina* by the presence of either a thick palisade cell layer in the exterior cortex overlying supportive tissue or a simpler, less distinct cortex; the presence of black, usually abundant pycnidia; a high concentration of triterpenes; and unattached agglutinated hyphal strands in most species except the ceruchoid group (Bowler and Riefner 1995).

B. Species Description

1. Morphology and Chemistry

N. cephalota (**Figure 20**) is characterized by a fruticose thallus, 2-4 cm, tufted to drooping, pale greenish but often black spotted, in the herbarium becoming covered with filamentous crystals (with the appearance of mold); branches mostly < 2 mm diameter, roundish and pitted; soredia lateral, tinged with bluish-gray; spot tests negative except cortex KC+yellow (McCune and Geiser 1997). Because the morphology is so variable, it can be mistaken for a parasitized *Ramalina*, especially the regionally common species, *R. farinacea*. The black spots are characteristic of the lichen rather than spots of infection, however

2. Reproductive Biology

Apothecia are unknown for this species. Asexual reproduction occurs by soredia. The microscopic size of the reproductive propagules should enable them to be carried long distances by wind, animals, or birds. Birds in particular are thought to enhance arrival rates of rare oceanic species like *N. cephalota* by dispersing lichen propagules along coastal migratory routes of the Pacific Northwest (McCune et al. 1997).

3. Ecological Roles

The genus *Niebla* is particularly well adapted to low annual rainfall, frequent overcast and fog with associated high humidity. In North America, these conditions are typically found along the California and Baja California coasts. In such habitats, species of *Niebla* and *Ramalina* can almost completely cover the branches of shrubs and other plants, and dominate ground surfaces such as rocks, loose volcanic cinders, soil, and even sand, and likely play a role in nutrient cycling (Rundel et al. 1972). Little is known about the ecological roles of *N. cephalota* in the Pacific Northwest. The closely related species, *N. ceruchoides*, functions as a seed trap and nursery for several vascular plants, specifically species of *Dudleya* (Crassulaceae), in areas farther south (Riefner and Bowler 1995).

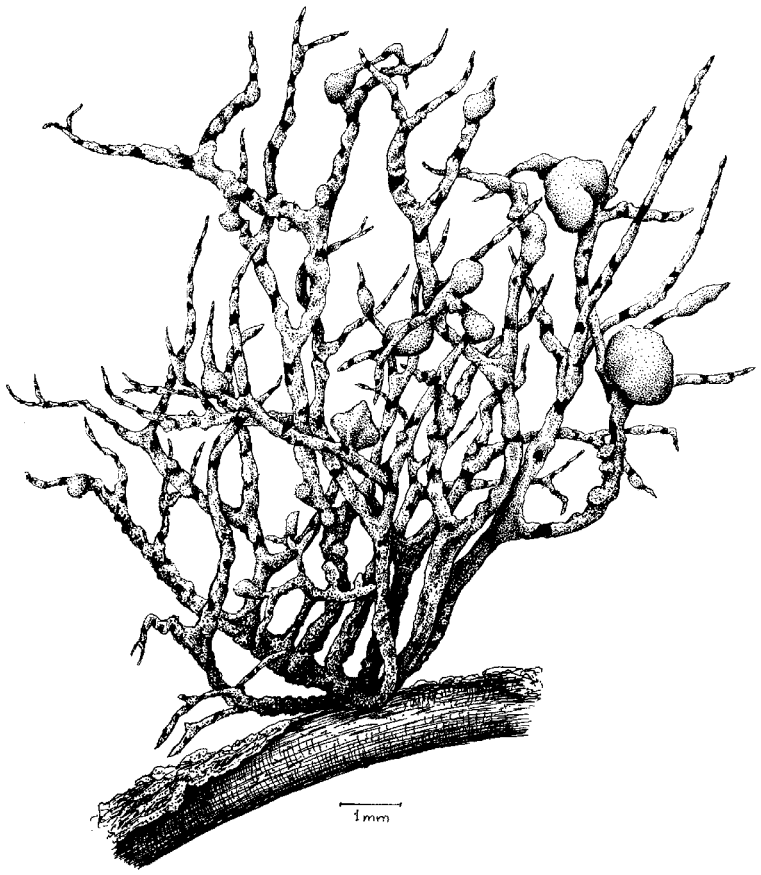

Figure 20. Drawing of *Niebla cephalota.*

C. Range and Known Sites

N. cephalota is endemic to western North America, ranging from Baja California north to Washington along the immediate coast. It belongs to a tropical genus with considerable species diversity and biomass along the coasts of southern California, the Channel Islands, and Baja California (Bowler and Riefner 1995). *N. cephalota* is the only species in the genus to range as far north as the Pacific Northwest. In Washington State, it is known from three sites, none on federal land. The land ownership for the Washington site in Roche Harbor on San Juan Island (San Juan County), is unknown because the collection record is vague. Recent Washington collections are from Deception Pass State Park (Island County) and Northwest Fidalgo Island (Skagit County). Only two of the six Oregon collections are on federal land: Sutton Creek Recreation Area, Siuslaw NF (Lane County), and Spinreel Campground in the Oregon Dunes National Recreation Area, administered by the Siuslaw NF (Coos County). Three Oregon records are from Cape Blanco State Park (Curry County), and one is from Cape Arago State Park (Coos County). The five California records are from the Samoa Peninsula (Humboldt County) and Patricks Point State Park (Humboldt County).

D. Habitat Characteristics and Species Abundance

Habitat characteristics and requirements of *N. cephalota* in the range of the Northwest Forest Plan, the northern extent of its distribution, are probably different for those farther south, where it is more common. Throughout its range, this species is found on trees, rocks, and shrubs and is restricted to the coastal fog belt. In the Pacific Northwest and northern California, *N. cephalota* has been found most often on exposed boles and branches of Sitka spruce (*Picea sitchensis*), but also on Monterey cypress *(Cupressus macrocarpa),* shore pine (*Pinus contorta*) and Hooker's willow (*Salix hookeriana*). The species grows on forest edges of windswept headlands and sand dunes; at the edge of tree islands surrounded by moving

dunes; as well as in sparsely forested estuaries and willow-dominated marshy areas. In one location it occurred on an old shore pine on the seaward edge of an old-growth Sitka spruce forest (McCune et al. 1997). All known sites within the range of the Northwest Forest Plan are less than 75 m (250 ft) elevation and within a few kilometers of the Pacific Ocean. Species abundance at known sites is undetermined.

II. CURRENT SPECIES SITUATION

A. Why Species Is Listed Under Survey and Manage Standard and Guideline

N. cephalota was considered at risk under the Northwest Forest Plan because of its rarity and limited distribution in the range of the northern spotted owl (USDA and USDI 1994a, 1994b). At the time, it was known from six sites in the range of the northern spotted owl (USDA and USDI 1994b). The viability ratings reflected a high level of concern for this species. The rare oceanic-influenced lichens as a group received the lowest viability ratings among all the lichens considered (USDA and USDI 1994a).

Because of the low viability ratings and high level of concern, this species was identified as a Survey and Manage Strategy 1 and 3 species (USDA and USDI 1994c), with the dual objectives of managing known sites and conducting extensive surveys to locate additional populations and identify other high-priority sites for species management.

B. Major Habitat and Viability Considerations

Frequent fog, and various ocean-influenced climatic, vegetative and soil factors, create the environment occupied by *N. cephalota.* Suitable habitats are sparse and are often separated by many miles. Given the limited availability of habitat, the high rate of human and natural disturbance to coastal habitats, and the slow colonization rates of *N. cephalota* (no large populations have been recorded), it seems likely that this species will continue to be rare within the range of the Northwest Forest Plan.

The major concerns for *N. cephalota* are the small number of known sites, the limited amount of suitable habitat for this species on federal land, and loss of populations from human activities that directly affect the remaining populations, habitat areas, or potential habitat. Climate changes, especially if they affect coastal fog regimes, and air pollution, are secondary concerns. Degradation or change in habitat conditions could affect the vigor of this species, possibly resulting in an even more restricted distribution or contributing to local extirpation.

Isolation of populations also leads to genetic isolation. Almost nothing is known about the genetics of lichen populations or the effects of gene pool isolation on local extinction rates of populations.

C. Threats to the Species

Threats to *N. cephalota* are those actions that disrupt stand conditions necessary for its survival. Such actions include treatments that reduce local populations by removing colonized bark or wood substrates; decreasing exposure to light; adversely affecting integrity of habitat areas; reducing or fragmenting potential habitat; or degrading air quality.

Recreational activities and developments may inadvertently alter the habitat of this species. Trampling by recreational vehicles and frequent foot traffic are serious threats, especially in shore pine woodlands and edge communities, as these degrade the habitat by disturbing fragile root systems of trees and shrubs, and the fragile protective mats of ground cryptogams, which stabilize the soil (Christy et al. 1998). Destabilization of the foredunes by recreationists or removal of European beachgrass (*Ammophila arenaria*) can destabilize tree island habitats of *N. cephalota* by increasing the amount of sand drift into

them and burying trees on the perimeter (Christy et al. 1998). Buildings, roads, campgrounds and trails along the immediate coast have replaced many natural habitats to improve access, facilitate scenic views, or develop recreational uses.

Other threats to the integrity of habitat and potential habitat areas include logging, grazing, agriculture, and activities which alter local hydrology, or increase fire frequency (Christy et al. 1998). Concern about fire varies— many different plant communities and successional stages exist among the coastal dunes and headlands; fire is beneficial to some communities but damaging to others. Invasion or planting of exotics such as Scots broom (*Cytisus scoparium*), European beachgrass, tree lupine (*Lupinus arboreus*), birdsfoot-trefoil (*Lotus corniculatus*), and iceplant (*Mesembryanthemum* spp.) can have profound effects on nitrogen-poor dune soils by increasing nitrogen and soil moisture. These conditions foster invasion of other weeds, eventually disrupting native plant communities (Christy et al. 1998) and reducing plant and animal diversity (USDI 1997).

The air pollution sensitivity of *N. cephalota* is unknown. Species in a related genus, *Ramalina*, have a wide range of sensitivity (McCune and Geiser 1997, Boonpragob and Nash 1991). Because the primary habitat of this lichen is the coastal fog belt, and because fog significantly concentrates pollutants— especially acidic forms of SO_x and NO_x to which lichens are most sensitive— the potential vulnerability of *N. cephalota* to air-quality deterioration is a reasonable concern. Although air quality is generally good at known sites, rising pollution emissions from increased traffic (mainly NO_x) and new or expanded point sources (SO_x and NO_x) in the Arcata/Eureka vicinity, and elsewhere along the coast, might threaten this species in the future.

Climate change affecting coastal fog patterns could be expected to affect the vigor of this species, possibly resulting in an even more restricted distribution or contributing to local extirpation.

D. Distribution Relative to Land Allocations

N. cephalota is known from only two sites on federal land, near Spinreel Campground and Sutton Creek Recreation Area; both are administered by the Siuslaw NF. It was not clear at the time of writing whether the site near Spinreel Campground is part of the Oregon Dunes National Recreation Area (Congressionally withdrawn) or just outside the Recreation Area. Sutton Creek Recreation Area on the Mapleton Ranger District, is administratively withdrawn and management emphasizes recreation. *N. cephalota* occurs on the Samoa Peninsula and may eventually be found in the Lanphere Dunes Unit (Humboldt Bay National Wildlife Refuge, USFWS). The Lanphere Dunes are managed to protect wildlife and native vegetation (USDI 1997).

III. MANAGEMENT GOAL AND OBJECTIVES

A. Management Goal for the Species

The goal for managing *N. cephalota* is to assist in maintaining species viability.

B. Specific Objectives

Manage populations at all known sites on federal lands by maintaining habitat and potential habitat immediately surrounding known populations.

IV. HABITAT MANAGEMENT

A. Lessons From History

Habitat destruction or alteration has made a significant contribution to the decline of lichens world-wide (Seaward 1977). Rare lichens, that occur in habitats optimal for human activities, such as the immediate coast, are especially vulnerable. At the northern Samoa Peninsula, on county and state land near the mouth of the Little River, the native dune communities have been nearly eliminated by the invasion of European beachgrass and human activities, and only a tiny fragment of the dune forest is left. Lichens are also absent from the southern end of the Peninsula's dune forest, where the trees are young and there is more off road vehicle evidence (Glavich, pers. comm.). At the Lanphere Dunes, even hiking has been documented to damage fragile shore pine/bearberry communities (Brown 1990). In coastal Oregon, activities of the past 140 years including increased logging, recreation, agriculture and grazing, fire, and changes in hydrology have significantly altered plant succession (Christy et al. 1998). For example, at Sand Lake dunes of Oregon, an area of high lichen diversity, off-road vehicles have destroyed nearly all the fragile shore pine woodland habitat in just thirty years (Wiedemann 1984, 1990 as cited by Christy et al. 1998).

Lichens have been known to be sensitive to air pollution for more than a century. Many species in Europe and eastern United States are in an active state of decline from sulfur dioxide, nitrogen oxides, and acidic deposition of sulfur- and nitrogen-containing pollutants (Ferry et al. 1973, Hawksworth and Rose 1976). Fog contains more dissolved ions and acidity than precipitation does (James and Wolseley 1992). Lichens that obtain most of their water from fog and dew are particularly vulnerable to air quality and weather pattern changes (Nash 1996). Follmann (1995) documented massive impoverishment and retrogression of lichens over much of the northern Chilean coastal fog belt over the past 20 years. Increasing frequency of El Niño events and gradually increasing aridity were postulated as likely, but not exclusively, causal factors in this decline. Species of *Niebla* and *Ramalina* are primary components of these communities. In the Pacific Northwest, sensitive species are already declining in some areas (Denison and Carpenter 1973, Taylor and Bell 1983) and lichens are identified as Air Quality Related Values in USDA Forest Service regional guidelines (Peterson et al. 1992).

B. Identifying Habitat Areas for Management

All known sites of *N. cephalota* on federal land administered by the Forest Service and BLM in the range of the Northwest Forest Plan are identified as habitat areas where these management recommendations should be implemented. A habitat area for management is defined as suitable habitat occupied by or near a known population.

C. Managing in Habitat Areas

The objective of managing in habitat areas is to maintain the habitat conditions for *N. cephalota*. Known habitat conditions are foggy coastal dunes and headlands with exposed old Sitka spruce, Hooker's willow, Monterey cypress, and shore pine.

- Determine the extent of the local population and habitat area with a site visit.
- Maintain suitable habitat around the current host trees and shrubs, so that the lichen may have adequate new substrate as current substrates decline.
- Develop practices to route human use away from the populations in habitat areas (e.g., divert roads, trails and off-road vehicles). Trampling shrubs or cryptogam mats, compacting roots, damaging trees or branches that serve as substrates, introducing non-native species by seed dispersal or planting, can all adversely affect habitat integrity.

- Avoid harvesting trees, shrubs, or other vegetation from the population and habitat area unless these actions would do no harm to, or would improve, the habitat for *N. cephalota* (e.g., by preventing deeply shaded conditions or by removing invasive exotics).
- Prevent fire in the population but utilize or prevent fire in habitat areas, depending on the role of fire in the plant community. Consider recommendations by Christy *et al*. (1998) for fire management in coastal plant communities.
- Maintain integrity of the foredunes where they protect habitat areas.
- Restrict commercial collection of moss, fungi or other special forest products if these activities would adversely affect the integrity of habitat areas.

D. Other Management Issues and Considerations

- Consider opportunities for managing known sites during Forest Plan and Resource Management Plan revisions, such as Botanical Special Interest Areas, Areas of Critical Environmental Concern, or other administratively withdrawn designations, or by prescribing special standards and guidelines.
- Provide information about conserving rare lichens at visitor centers or other locations along the coast to build public support of conservation efforts and to discourage collection of specimens.
- Continue to work with state and federal regulatory agencies to protect air quality on federally-managed lands from on- or off-site emissions, especially of nitrogen- and sulfur-containing pollutants.
- Share information with State and private sectors to further activities directed at conserving *N. cephalota.*

V. RESEARCH, INVENTORY, AND MONITORING NEEDS

The objective of this section is to identify opportunities to acquire additional information that could contribute to more effective species management. The content of this section has not been prioritized or reviewed as to how important the particular items are for species management. The inventory, research, and monitoring identified below are not required. These recommendations should be addressed by a regional coordinating staff.

A. Data Gaps and Information Needs

- Determine if *N. cephalota* meets the criteria for being closely associated with late-successional or old-growth forests.
- Visit known sites to describe the geographical extent of local populations and their habitat.
- Determine whether additional populations exist in areas identified as potentially suitable habitat. Potentially suitable habitat is identified as stabilized deflation plain dunes and swales with Hooker's willow, and foggy, coastal, windswept headlands and dunes with scattered old Sitka spruce and Monterey cypress. Areas with the most potential suitable habitat on federal land include Sutton Creek Recreation Area, Gwynn Creek, Eel Creek Recreation Area, and interdune tree islands and scrub forests of the Oregon Dunes National Recreation Area, all on the Siuslaw NF; BLM parcels adjacent to Cape Lookout, and other coastal BLM parcels. Other under-explored federally managed land along the immediate coast include Olympic National Park seashore and the Willapa National Wildlife Refuge.
- Assign priority to Strategy 3 surveys in areas where management treatments or projects are scheduled or proposed.

B. Research Questions

- What are the dispersal and growth rates of *N. cephalota*?

- Which habitat characteristics are necessary for survival of *N. cephalota* propagules and colonies? Are some conditions unique to old-growth habitats critical to the survival of this species? Can stands be managed to mimic those characteristics?
- What are the minimum and optimum patch sizes of colonized habitat necessary to provide for *N. cephalota*?
- How can young managed stands along the immediate coast be managed to conserve and promote populations of rare lichens?
- What is the air quality sensitivity of *N. cephalota*?

C. Monitoring Needs and Recommendations

- Monitor known sites for changes in micro-climatic conditions, successional changes, and for inadvertent habitat damage from human activities or wildfire.
- Monitor dispersal and population trends of existing populations.
- Monitor air quality near key populations of *N. cephalota* on federally-managed lands and assess threats to this species from present or projected air-quality trends.

Pannaria rubiginosa

SUMMARY

Species: *Pannaria rubiginosa* (Ach.) Bory
Taxonomic Group: Lichens (Rare Nitrogen-fixing)
ROD Components: 1, 3

Other Management Status: Oregon Natural Heritage Program List 3 (more information is needed before status can be determined, but which may be threatened or endangered in Oregon or throughout their range). Natural Heritage Network Ranks Oregon State Rank S1 (critically imperiled because of extreme rarity or because it is somehow especially vulnerable to extinction or extirpation, typically with 5 or fewer occurrences). Global Rank G4 (not rare and apparently secure, but with cause for long-term concern, usually with more than 100 occurrences) (Oregon Natural Heritage Program 1998). BLM Bureau Tracking Status in Oregon (USDI, BLM 1998).

Range: The distribution of *Pannaria rubiginosa* in the Pacific Northwest is scattered and discontinuous, ranging from west of the Cascade Crest from British Columbia south to California and New Mexico. In the range of the northern spotted owl, *P. rubiginosa* has been documented from four sites in Oregon: BLM land in Lane and Marion Counties, Siuslaw NF and Beaver Creek Marsh (Lincoln County). In Washington, it is reported from three historical collections in taxonomic question (Pacific, Kittitas, and Pierce Counties). *P. rubiginosa* was recently reported from Humboldt County, California.

Specific Habitat: Habitat information is limited for this species in the range of the northern spotted owl. Current information suggests it is found at low elevations, with sites ranging from 15-487 m (50-1600 ft). It grows in mature Douglas-fir/western hemlock forest, old-growth conifer forest dominated by Douglas-fir, Sitka spruce, and western redcedar, and shrub thickets of willow and ericaceous shrubs in the dune and deflation plain habitat, where it is epiphytic on Hooker's willow. The habitat at the California site is a creek site in a late mature forest of Douglas-fir, tan oak and madrone with associated hardwoods and shrubs.

Threats: The major threat to *P. rubiginosa* is loss of populations resulting from activities that directly affect the habitat or the population, including removing colonized substrate and altering microclimate. Other threats to populations include recreational impacts in coastal habitats, and collection of specimens for scientific purposes. The air pollution sensitivity of this species is unknown.

Management Recommendations:
- Manage populations at known sites by maintaining the ecological conditions associated with *P. rubiginosa*, including stand structure, substrate and microclimate.
- Restrict collection of specimens where the species is rare or of limited abundance.

Information Needs:
- Revisit known sites to determine the extent of local populations and improve habitat information.
- Determine if *P. rubiginosa* is closely associated with late-successional or old-growth forests.
- Determine the status of the historical collections and locations in Washington.

Pannaria rubiginosa.

I. NATURAL HISTORY

A. Taxonomy and Nomenclature

Pannaria rubiginosa (Ach.) Bory was originally described by Acharius in the 19th century. This species is treated in the monograph of the Pannariaceae in Europe (Jorgensen 1978) and in a revision of North American Pannariaceae (Jorgensen 2000). It is in the order Lecanorales, suborder Peltigerineae, family Pannariaceae (Tehler 1996).

B. Species Description

1. Morphology and Chemistry

P. rubiginosa is an inconspicuous lichen, readily recognized by its small foliose rosettes with elongated lobes, and brown to red-brown apothecia with an even thalline rim (**Figure 21**) (McCune and Geiser 1997). It has a PD+ orange-red medullary reaction, unique among other Pacific Northwest *Pannaria* species. The thallus is blue-gray, lobes are narrow and can appear distinctly squamulose, especially at the center. In exposed sites, the thallus becomes darker and olivaceous (Purvis et al. 1992).

Technical Description: Thallus foliose, forming rosettes to 2-3 cm in diameter with marginal lobes; upper surface whitish gray-blue to brown or olive; lobes 3-4 mm x 7-8 mm, deeply indented and mostly concave with thick, pale, ascending margins; surface smooth, more or less faintly scabrid or occasionally thin pruinose; hypothallus fibrous, well developed, obscure or sometimes extending as a blue-black zone surrounding the thallus. Photobiont is the cyanobacterium *Nostoc*. Apothecia 0.5-1.5 mm in diameter, frequent; disc red-brown; thalline exciple prominent, persistent, often crenulate. Ascospores 15-19 µm x 9-10 µm, with perispore 20-24 µm x 10-12 µm, colorless, ellipsoid; perispore uneven, acuminate at one or both ends. Medulla PD+ orange-red (pannarin) (Purvis *et al*. 1992:421).

2. Reproductive Biology

P. rubiginosa reproduces sexually by ascospores; asexual propagules are unknown.

3. Ecological Roles

Little is known about the ecological role of *P. rubiginosa* in the range of the northern spotted owl. It is a nitrogen-fixing species.

C. Range and Known Sites

P. rubiginosa is broadly distributed globally, on all continents except Australia (Purvis *et al*. 1992). Its distribution in the Pacific Northwest is scattered and widespread (McCune and Geiser 1997). It is found west of the Cascades from British Columbia south to California and New Mexico.

In the Pacific Northwest, *P. rubiginosa* is known from three sites in Washington State from historical collections that need verification (Pacific, Kittitas, and Pierce Counties). The taxonomic identity of these collections is in question and should be verified by a qualified lichenologist. *P. rubiginosa* has been collected from three places in Oregon. It is known from Eugene District BLM Heceta Dunes Area of Critical Environmental Concern (Lane County), Siuslaw NF on Lower Canal Creek near Waldport (Lincoln County), and the Beaver Creek Marsh (Lincoln County, ownership unknown) (McCune *et al*. 1997). In California, *P. rubiginosa* has recently been reported from Kings Peak Road in Humboldt County. It is also reported from San Mateo County, which is south of the area covered by the Northwest Forest Plan. All the California collections should be re-examined to distinguish them from *P. malmei*, which has a P+ orange cortical reaction but a P- medullary reaction.

D. Habitat Characteristics and Species Abundance

P. rubiginosa appears to be rare in the Pacific Northwest. Current information suggests it is a low-elevation species, with sites ranging in elevation from 15-487 m (50-1600 ft). Habitat data are limited, but *P. rubiginosa* appears to grow in a variety of habitats. Its largest known populations in this region are on the Oregon Coast in coastal shrub thickets on wet deflation plains (McCune and Geiser 1997, McCune et al. 1997).

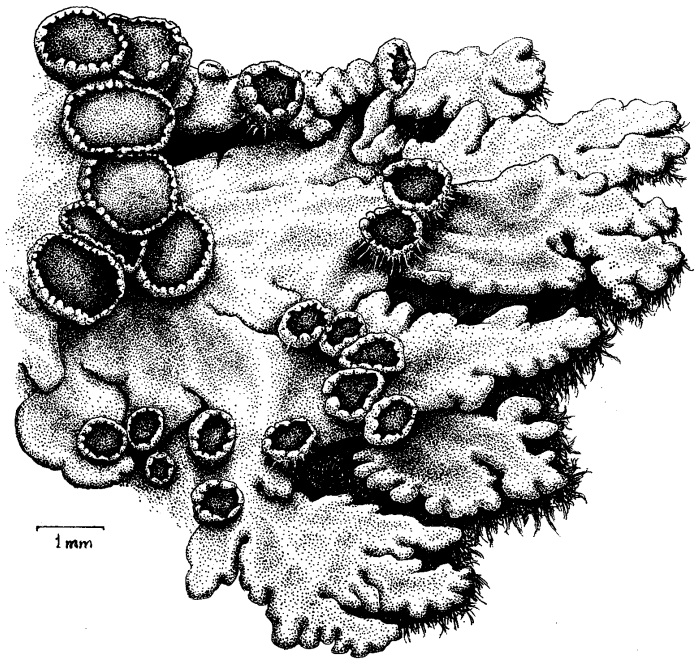

Figure 21. Drawing of *Pannaria rubiginosa.*

The Oregon Coast sites at 15 m (50 ft) elevation are noted as a Hooker's willow (*Salix hookeriana*) thicket near vernal-pool lowlands, and a shady willow/ericaceous shrub thicket in dune and wetland mosaic amid patchy forests of shore pine (*Pinus contorta*) and Sitka spruce (*Picea sitchensis*). The shrub thickets at the latter site were rich in cyanolichen diversity. *P. rubiginosa* was reported as an epiphyte on Hooker's willow at both sites. At the Siuslaw NF site, 30 m (100 ft) elevation, *P. rubiginosa* was found in litterfall in an old-growth conifer forest dominated by Douglas-fir and western redcedar (*Thuja plicata*), with Sitka spruce and red alder (*Alnus rubra*).

The site in Humboldt County, California, is reported as a creek in a late-mature forest of Douglas-fir, tanoak (*Lithocarpus densiflorus*), and Pacific madrone (*Arbutus menziesii*), with associated hardwoods and shrubs. The elevation ranged from 463-487 m (1520-1600 ft).

II. CURRENT SPECIES SITUATION

A. Why Species Is Listed Under Survey and Manage Standard and Guideline

P. rubiginosa was considered at risk under the Northwest Forest Plan because of its presumed rarity in the range of the northern spotted owl. At the time of the FEMAT viability rating (USDA and USDI 1994a) and additional species analysis (USDA and USDI 1994b), this species was reported from only two sites in the region. Viability concerns were also noted for this species because of its presumed sensitivity to air pollution inferred by the known sensitivity of other nitrogen-fixing lichens. The pollution sensitivity of *P. rubiginosa* is unknown, however.

There was a high level of concern for the persistence of this species. Because of persistence concerns, it was listed as a Survey and Manage Strategy 1 and 3 species (USDA and USDI 1994c), with the objectives to manage known sites and to conduct extensive surveys to identify high priority sites for management.

B. Major Habitat and Viability Considerations

The major viability considerations for *P. rubiginosa* are loss of populations resulting from management or other activities that affect the populations or their habitat. The occurrence of *P. rubiginosa* in different habitats, and in young and mature stands, suggests that it may have a broader ecological amplitude than was known at the time of the viability rating (USDA and USDI 1994a, 1994b).

C. Threats to the Species

Threats to *P. rubiginosa* are those actions that disrupt stand conditions necessary for its survival, including treatments that may directly or indirectly affect populations such as removing colonized substrate, stand treatments that change microclimate, effects from recreational activities and development, or possibly a significant deterioration in air quality. Collection of voucher specimens for scientific purposes may also threaten this species because few individuals are known to exist in this region.

D. Distribution Relative to Land Allocations

The distribution of known sites of *P. rubiginosa* relative to land allocations needs to be determined. The Heceta Dunes is managed as an Area of Critical Environmental Concern by the Eugene District BLM. Each administrative unit should evaluate the land allocations for known sites on lands within its jurisdiction, and share this information at the regional level.

III. MANAGEMENT GOAL AND OBJECTIVES

A. Management Goal for the Species

The goal for managing *P. rubiginosa* is to assist in maintaining species viability.

B. Objectives

Manage known sites on federal lands by maintaining habitat, stand structure, occupied and potential suitable substrate, and micro-climatic conditions associated with *P. rubiginosa*.

IV. HABITAT MANAGEMENT

A. Lessons From History

Very little is known about the ecology of *P. rubiginosa* in the Pacific Northwest, or how past actions have affected its distribution or persistence. Concerns have been expressed about the sensitivity of this species to air pollution, however.

Many lichen species are known to be sensitive to air pollution, and lichen population declines attributed to air pollution have been documented in Europe and North America (Rao and LeBlanc 1967, Skye and Hallberg 1969, Hawksworth 1971, Ferry et al. 1973, Hawksworth and Rose 1976, Case 1980, Sigal and Nash 1983, Gilbert 1992). Many nitrogen-fixing lichen species are especially sensitive to air pollution, particularly sulfur dioxide (Wetmore 1983). The sensitivity of *P. rubiginosa* to air pollution is unknown, but, based on the known sensitivity of other nitrogen-fixing lichens, *P. rubiginosa* is likely to also be sensitive to air pollution.

The decline of lichens in Europe has resulted in listing threatened species. Sweden has a “red list” of lichens that are threatened with extinction because of air pollution and habitat degradation (Thor 1990); *P. rubiginosa* is on this list as endangered (Databanken for hotade arter och Naturvardsverket 1991).

B. Identifying Habitat Areas for Management

All known sites of *P. rubiginosa* on lands administered by the Forest Service and BLM in the range of the northern spotted owl are identified as habitat areas where these management recommendations apply. A habitat area is defined as suitable habitat occupied by or adjacent to a known population.

C. Managing in Habitat Areas

- Determine the extent of the local population and habitat area with a field visit.
- Manage habitat areas to maintain the ecological conditions associated with *P. rubiginosa*, including stand structure, occupied and potentially suitable substrate, and associated micro-climatic conditions. Current habitat conditions should be maintained at all locations, and be allowed to develop naturally.
- Avoid disturbance to occupied substrate.
- Restrict collecting of specimens where the species is rare or of limited abundance.
- Manage habitat areas in coastal willow thickets to minimize recreation impacts to local populations and their habitat, including minimizing impacts to occupied and potentially suitable substrates.

D. Other Management Issues and Considerations

P. rubiginosa is a small, inconspicuous species. Additional populations may be found with surveys in suitable habitats.

Populations of this species may exist on non-federal lands, and these populations will contribute to the species' persistence. Share information with State and private sectors, including Oregon State Parks and Highway Department to further activities directed at the conservation of this species on non-federal lands, especially along the Oregon Coast.

Limited habitat data is available for *P. rubiginosa*. However, the current information suggests that *P. rubiginosa* may not meet the criteria for close association with late-successional or old-growth forests (USDA and USDI 1994a [Table IV-6], 1994b). For a species to be appropriately listed as a Survey and Manage species, it must first meet the criteria established for designation as a species closely associated with late-successional or old-growth forests. This issue should be addressed by a regional coordinating staff.

V. RESEARCH, INVENTORY, AND MONITORING NEEDS

The objective of this section is to identify opportunities to acquire additional information which could contribute to more effective species management. The content of this section has not been prioritized or reviewed as to how important the particular items are for species management. The inventory, research, and monitoring identified below are not required. These recommendations should be addressed by a regional coordinating staff.

A. Data Gaps and Information Needs

- Revisit known sites to verify the status of known populations, determine the extent of the populations, and characterize the ecological conditions.
- Determine if *P. rubiginosa* meets the criteria for being closely associated with late-successional or old-growth forests.
- Verify the taxonomic identity of the historical collections from Washington. If verified as *P. rubiginosa*, attempt to locate the populations if they occur on federal land.

- Determine if additional populations of *P. rubiginosa* exist in areas identified as potentially suitable habitat.

B. Research Questions

- What habitat characteristics and ecological conditions are necessary for the establishment of *P. rubiginosa* propagules and survival of established thalli?
- What are the dispersal mechanisms and dispersal distances of *P. rubiginosa*?
- Is *P. rubiginosa* sensitive to air pollution?
- What are the mechanisms and rates of reproduction and growth for this species?
- What is the genetic diversity of this species within its local populations and across the region?

C. Monitoring Needs and Recommendations

If management treatments occur adjacent to known sites, monitor the population to determine response to treatment and effects on the population.

Pilophorus nigricaulis

SUMMARY

Species: *Pilophorus nigricaulis* Sato
Taxonomic Group: Lichens (Rare Rock)
ROD Components: 1, 3

Other Management Status: Oregon Natural Heritage Program List 2 (threatened with extirpation or presumed to be extirpated from the State of Oregon). Natural Heritage Network Ranks Oregon State Rank S2 (imperiled because of rarity or because other factors demonstrably make it very vulnerable to extinction (extirpation), typically with 6-20 occurrences). Global Rank G4 (not rare and apparently secure, but with cause for long-term concern, usually with more than 100 occurrences) (Oregon Natural Heritage Program 1998). BLM Bureau Assessment Status in Oregon (USDI, BLM 1998).

Range: *Pilophorus nigricaulis* is rare throughout its range, known only from Japan and the west coast of North America, from Alaska south to Washington and Oregon, west of the Cascade crest. It is reported from 16 sites in the range of the northern spotted owl, and reaches the southern extent of its range in northern Oregon. Most known sites are on federal lands and include the Mt. Baker-Snoqualmie, Gifford Pinchot, and Willamette NFs, Columbia River Gorge National Scenic Area and Salem District BLM.

Specific Habitat: *P. nigricaulis* grows on rock substrates from 40-1430 m (130-4700 ft) elevation, it is primarily found in non-forest communities on talus slopes, cliffs, rock outcrops, and large boulders; it may also occur on these substrates within a forest setting. Volcanic rock is the predominant substrate reported. Adjacent vegetation has been noted as old-growth forests, vine maple communities, subalpine parkland, and cryptogam-dominated communities.

Threats: The major threat to *P. nigricaulis* is loss of populations resulting from activities that affect the population or its habitat, including effects on or removing colonized substrate, altering micro-climatic conditions, and collecting specimens where the species is rare. As a nitrogen-fixing species, *P. nigricaulis* may be sensitive to air pollution.

Management Recommendations:

- Manage populations of the species at known sites by maintaining the ecological conditions associated with *P. nigricaulis*, including occupied substrate and associated microclimate and stand conditions.
- Restrict collection of specimens where the species is rare or of limited abundance.
- Minimize effects to substrate occupied by *P. nigricaulis*.

Information Needs:

- Determine if *P. nigricaulis* meets the criteria established for designating a species as closely associated with late-successional or old-growth forests.
- Determine distribution of populations, species abundance, and ecological requirements of *P. nigricaulis* in the area covered by the Northwest Forest Plan.

Pilophorus nigricaulis

I. NATURAL HISTORY

A. Taxonomy and Nomenclature

Pilophorus nigricaulis Sato was described in 1940 (Journ. Jap. Bot. 16:173). It is in the order Lecanorales, suborder Cladoniineae, family Stereocaulaceae (Tehler 1996). There are no known synonyms.

B. Species Description

1. Morphology

P. nigricaulis is a distinctive but relatively inconspicuous rock-dwelling lichen (**Figure 22**). It has very short stalks arising from a white crustose primary thallus; stalks are simple with a blackish core and scattered to continuous white warts or areoles, < 5 mm tall, about 1 mm diameter. Some stalks may have terminal roundish black apothecia (McCune and Geiser 1997). It can be seen from a distance as a bright white, crustose-appearing thallus growing directly over rock, contrasting with the surrounding darker lichens and bryophytes; on closer inspection, the stalks can be seen (McCune and Geiser 1997). The basal cephalodia fix atmospheric nitrogen.

Technical Description: Horizontal thallus persistent, white or light gray, granular. Granules about 2 mm high and 1 mm broad, subglobose, aggregated or scattered on the substrate. Most granules slightly peltate. Pseudopodetia pin-like, 1-6 mm high, 1 mm in diameter. Internally, the stalks are compact, composed of strongly gelatinized hyphae, colored black by the deposition of dark pigment granules. The pseudopodetia are covered by subglobose granules of the same color, morphology, and structure as the granules of the horizontal thallus. In some specimens, a few stalks are branched. Pycnidia apical on short pseudopodetia or sessile on the horizontal thallus. Conidiophores long, slightly branched with terminal sickle-shaped conidia. Apothecia terminal on mature pseudopodetia or sometimes sessile on the horizontal thallus, 1.0-2.5 mm in diameter. Apothecial margin downturned as far as the point of attachment to the stalk. Apothecia subglobose or slightly conical. No columella is present. Apothecium and pseudopodetium separated by a broad boundary texture. No pigment boundary is present. Hymenium about 180 μm high, subhymenium 120 μm. Excipulum absent. Asci eight-spored. Spores rounded when young, becoming spindle-shaped when mature, about 18 x 7 μm. Photobiont green, *Pleurococcus* type. Cephalodia on the horizontal thallus, thick, brown to black, with wrinkled surface, about 0.5 mm in diameter, containing the cyanobacterium *Stigonema* (Jahns 1981).

2. Reproductive Biology

P. nigricaulis reproduces sexually by producing ascospores in apothecia.

3. Ecological Roles

Very little is known about the ecological role of *P. nigricaulis*. This species contains cyanobacteria, so it is able to fix atmospheric nitrogen.

C. Range and Known Sites

P. nigricaulis occurs in Japan and on the west coast of North America, from Alaska south to British Columbia, Washington, and Oregon, west of the Cascade crest (Jahns 1981). Within the range of the northern spotted owl, this species has been reported from 16 sites, seven in Washington and nine in Oregon. All but one of the reported sites is on federal land. In Washington, the species is reported from

Whatcom, King, Lewis and Skamania Counties and, in Oregon, from Multnomah, Hood River, Marion, Linn, and Lincoln Counties. On the Mt. Baker-Snoqualmie NF, it is reported from three sites: Austin Pass in the Mt. Baker area, Sulphur Creek Lava Flow, and Franklin Falls near Snoqualmie Pass. The taxonomic identity needs to be verified at the Sulphur Creek Lava Flow site. Four sites are reported on the Gifford Pinchot NF: Cowlitz Valley Ranger District on Forest Road 74 near milepost 22, the Mineral Block, Lava Cast Wayside on the south side of Mt. St. Helens, and a Current Vegetation Survey (CVS) plot. In Oregon, it is known from several sites in the Columbia River Gorge National Scenic Area: east of Multnomah Falls, on the Gorge Trail 400 east of McCord Creek, on Gorge trail 400 west of Wyeth, Eagle Creek trail, and Herman Creek Trail 406 to the Pacific Crest Trail. It is also found near Opal Creek on the Willamette NF, and from two sites on Salem District BLM: Carolyn's Crown Proposed Research Natural Area near Crabtree Lake, and Shaffer Creek Research Natural Area/Area of Critical Environmental Concern.

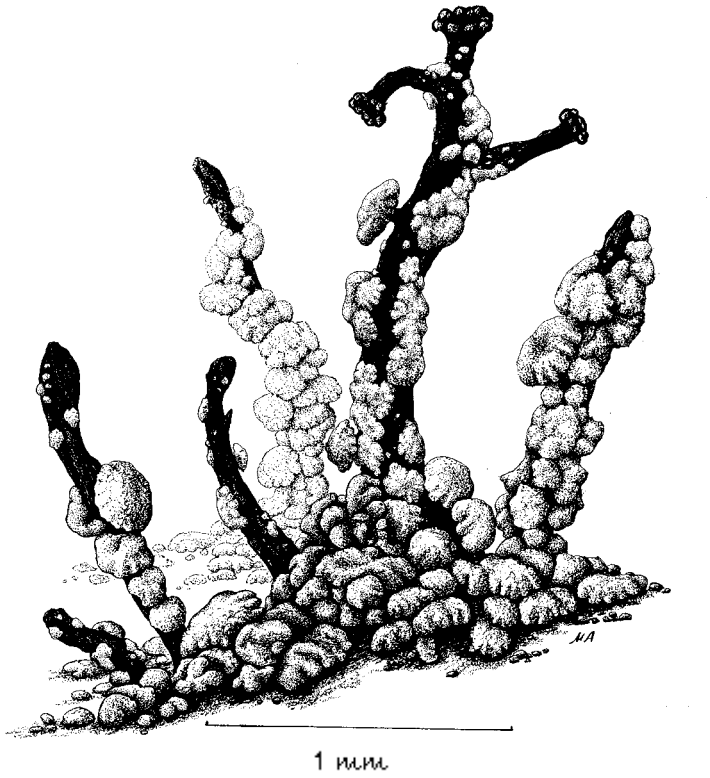

Figure 22. Drawing of *Pilophorus nigricaulis.*

D. Habitat Characteristics and Species Abundance

P. nigricaulis grows primarily on volcanic rock substrates (basalt and andesite). Habitats have been described as lava flows, cliffs, rock outcrops, talus slopes, and large boulders. Observations of known site habitats in the Columbia River Gorge report fairly stable substrate conditions. The elevation ranges from 40-1430 m (130-4700 ft). This lichen grows on rock substrates in a variety of plant communities, including low- to mid-elevation old-growth conifer forests dominated by Douglas-fir (*Pseudotsuga menziesii*), true fir (*Abies* spp.) and western hemlock (*Tsuga heterophylla*), shrub communities dominated by vine maple (*Acer circinatum*), subalpine parkland, or in open sites on rock associated with other cryptogams— such as *Cladonia, Stereocaulon* and *Racomitrium*.

P. nigricaulis is reported as rare throughout its range. However, several populations in the Columbia River Gorge are reported to have large colonies consisting of several hundred individuals (Davis, pers. comm.).

II. CURRENT SPECIES SITUATION

A. Why Species Is Listed Under Survey and Manage Standard and Guideline

P. nigricaulis was considered at risk under the Northwest Forest Plan because of its presumed rarity and limited distribution within the range of the northern spotted owl (USDA and USDI 1994a, 1994b). This

species is sporadically distributed throughout the region and may be rare at some sites. At the time of the lichen viability panel, *P. nigricaulis* was known from two sites in Oregon and three in Washington (USDA and USDI 1994a, 1994b). Concern for persistence was noted for lichens in general because of their sensitivity to air pollution, however the pollution sensitivity of *P. nigricaulis* is not known. The concern for *P. nigricaulis* may increase if this species is found to be sensitive to air pollution. *P. nigricaulis* was listed under the Survey and Manage strategies 1 and 3 to manage known sites and to conduct extensive surveys to identify high priority sites for management (USDA and USDI 1994c).

B. Major Habitat and Viability Considerations

The major viability consideration for *P. nigricaulis* is loss of populations resulting from management activities that affect the populations or the habitat. A major consideration would be quarrying or road building that directly affects the colonized rock substrates. Current information suggests this species is not restricted to and may not be closely associated with late-successional or old-growth forests. Many sites are in areas where timber harvest is presently not a threat, that is, areas withdrawn from the commercial timber base or non-forested sites. Some known sites indicate habitat as rock substrates in an old-growth forest matrix, however. Removing forest canopy and subsequent changes in microclimate may affect *P. nigricaulis* in these places. A warming climate may stress populations at the limits of a species range and could result in a decline in vigor and a more restricted distribution of *P. nigricaulis*. Many of the known sites are in the Columbia River Gorge and may be more susceptible to air pollution effects, given the vicinity to the Portland metropolitan area and other pollution sources.

Additional information acquired since the original viability rating of *P. nigricaulis* provides more sites than previously known. With additional surveys in suitable habitat, this species may not be as rare as previously thought. *P. nigricaulis* appears restricted in its ecological amplitude, however, and thus is limited in distribution partly because of the specificity of its habitat requirements.

C. Threats to the Species

Threats to *P. nigricaulis* are those actions that disrupt habitat conditions necessary for its survival, including treatments that destroy populations by quarrying and road building, or stand treatments that alter the microclimate. As a nitrogen-fixing species, *P. nigricaulis* may be affected by a significant deterioration of air quality. Collecting specimens may be a threat where the species is rare or of limited abundance.

D. Distribution Relative to Land Allocations

The distribution of known sites of *P. nigricaulis* relative to land allocations needs to be determined. Each administrative unit should evaluate the land allocations for known sites on lands within its jurisdiction, and share this information at the regional level.

III. MANAGEMENT GOAL AND OBJECTIVES

A. Management Goal for the Species

The goal for managing *P. nigricaulis* is to assist in maintaining species viability.

B. Objectives

Manage known sites on federal lands by maintaining habitat, stand structure, occupied and potential suitable substrate, and micro-climatic conditions associated with *P. nigricaulis*.

IV. HABITAT MANAGEMENT

A. Lessons From History

Very little is known about the ecology of this species, or how past actions have affected its distribution or viability. But, many lichen species are known to be sensitive to air pollution, and lichen population declines attributed to air pollution have been documented in Europe and North America (Rao and LeBlanc 1967, Skye and Hallberg 1969, Hawksworth 1971, Ferry et al. 1973, Hawksworth and Rose 1976, Case 1980, Sigal and Nash 1983, Gilbert 1992). The air pollution sensitivity of *P. nigricaulis* is unknown; but it may be sensitive to pollution, as other nitrogen-fixing lichen species have been shown to be.

B. Identifying Habitat Areas for Management

All known sites of *P. nigricaulis* on federal lands administered by the Forest Service and BLM within the range of the northern spotted owl are identified as habitat areas where these management recommendations apply. A habitat area for management is defined as suitable habitat occupied by or adjacent to a known population.

C. Managing In Habitat Areas

The goal of managing in habitat areas is to maintain the habitat conditions of the local population and minimize impacts to *P. nigricaulis*.

- Determine the extent of the local population and habitat area with a field visit.
- The local population should be managed to include an area that is large enough to maintain the habitat and associated microclimate of the population.
- Maintain occupied or potentially suitable substrate within the habitat area.
- Minimize effects to substrates occupied by *P. nigricaulis*, and restrict activities such as quarrying and road building in habitat areas.
- Restrict collection of specimens where the species is rare or of limited abundance.

D. Other Management Issues and Considerations

Information from reported sites suggests that *P. nigricaulis* may not be closely associated with late-successional or old-growth forests. For a species to be appropriately listed as a Survey and Manage species, it must first meet the criteria for designating a species as closely associated with late-successional or old-growth forests (USDA and USDI 1994a [Table IV-6] and 1994b). This issue should be addressed by a regional coordinating staff.

Current information suggests that *P. nigricaulis* is sporadic in its distribution, and appears to be rare. However, this rarity may be a function of limited surveys or inventories in suitable habitat. Given the apparent rarity of this species, it should be evaluated for inclusion in the agency sensitive species programs.

V. RESEARCH, INVENTORY, AND MONITORING NEEDS

The objective of this section is to identify opportunities to acquire additional information that could contribute to more effective species management. The content of this section has not been prioritized or reviewed as to how important the particular items are for species management. The inventory, research, and monitoring identified below are not required. These recommendations should be addressed by a

regional coordinating staff.

A. Data Gaps and Information Needs

- Determine if *P. nigricaulis* is closely associated with late-successional or old-growth forests following the criteria established in the FEMAT report.
- Revisit known sites to verify the status of known populations, determine the extent of the populations and abundance, and characterize ecological conditions.
- Verify the taxonomic identity of the population reported from the Sulphur Creek Lava Flow on the Mt. Baker-Snoqualmie NF.
- Determine the distribution of *P. nigricaulis* in areas identified as potentially suitable habitat.

B. Research Questions

- What habitat characteristics and ecological conditions are necessary for the establishment of *P. nigricaulis* propagules and the survival of established thalli?
- What are the dispersal mechanisms and dispersal distances of *P. nigricaulis*?
- What is the genetic diversity of this species within its local populations and across the region?
- Is *P. nigricaulis* sensitive to air pollution?

C. Monitoring Needs and Recommendations

If management treatments occur near known sites, monitor populations to determine their response to treatment and effects on the local population.

Pseudocyphellaria perpetua

(Formerly *Pseudocyphellaria mougeotiana*)

SUMMARY

Species: *Pseudocyphellaria perpetua* McCune & Miadlikowska [erroneously called *Pseudocyphellaria mougeotiana* (Delise) Vainio in the Record of Decision (USDA and USDI 1994c)].
Taxonomic Group: Lichens (Rare Oceanic-Influenced)
ROD Components: 1, 3

Other Management Status: Considered for inclusion on rare lichen working list by the Oregon Natural Heritage Program (1995), but rejected because of taxonomic uncertainty.

Range: *Pseudocyphellaria perpetua* is known from only three sites in the Pacific Northwest, all on the Oregon Coast: Gwynn Creek Trail in Gwynn Creek Special Interest Area (Siuslaw NF), and near Clear Lake and Rock Creek, both north of Florence.

Specific Habitat: *P. perpetua* was found in conifer litter in a riparian old-growth Sitka spruce, Douglas-fir, and western hemlock forest on the immediate coast, and on shaded branches of bristly manzanita in an unspecified shrub community on stabilized sand dune.

Threats: The major threat to *P. perpetua* is loss of local populations resulting from activities that adversely affect the habitat or local populations, including removing colonized substrate, altering the microclimate, and collecting voucher specimens. Because *P. perpetua* is known from only three sites, impact to these sites or habitat areas could result in extirpation of the lichen. Altering potentially suitable habitat could also threaten the lichen by rendering nearby habitat unsuitable to colonization. *P. perpetua* could also be threatened by air pollution and air quality degradation.

Management Recommendations:
- Maintain known sites of *P. perpetua* by allowing existing habitat conditions to persist and evolve naturally.
- Restrict collecting of voucher specimens to litterfall only, and deposit in accredited herbarium.
- Minimize air pollution impacts to the site.

Information Needs:
- Determine the taxonomic status of *P. perpetua* and its relation to Pacific Northwest, Hawaiian, and New Zealand *P. crocata*, or a similar Asian species.
- Verify the current status of the three local populations of *P. perpetua*.
- Survey potentially suitable habitat at Sutton Creek and Eel Creek Recreation Areas, and Sand Lake, Siuslaw NF; BLM Heceta Beach ACEC; BLM parcels adjacent to Cape Lookout, and other coastal BLM parcels.

I. NATURAL HISTORY

A. Taxonomy and Nomenclature

In the Pacific Northwest, the names *P. aurata, P. crocata,* and *P. mougeotiana* have all been applied to large foliose lichens with yellowish soredia. The lichen in question, however, is morphologically distinct from *P. crocata* in North America and has narrower habitat restrictions (McCune et al. 1997). Genetic, morphological and ecological differences from *P. crocata* were recently evaluated and a new epithet, *P. perpetua*, was created to encompass this species from the Oregon Coast and Far East Russia (Miadlikowska *et al*. 2001). The material erroneously referred to as *P. mougeotiana* (USDA and USDI 1994a, 1994b, 1994c) should now be referred to as *P. perpetua* McCune & Miadlikowska. The epithet refers to Cape Perpetua, a prominent headland on the Oregon Coast, named for St. Perpetua by Capt. James Cook in 1778. The only large populations known for this species in the Northwest Forest Plan Area occur around Cape Perpetua. The epipthet also alludes to the long historical continuity of the old *Picea sitchensis* forests that it frequents and which had already stood for centuries at the time of Cook's discovery.

B. Species Description

1. Morphology

P. perpetua, which has variously been called *P. mougeotiana*, *P. aurata* or *P. crocata* in the past, is morphologically distinct from all three of those species. *P. perpetua* has narrow, linear lobes, almost exclusively marginal soralia, a yellow medulla, a pale lower surface and a blue-green photobiont (**Figure 23**) (Miadlikowska et al. 2001). The upper cortex is UV+ pale bluish; the medulla and soralia are K+ yellow, C+ and KC+ orange (fleeting), UV- or dark reddish. *P. aurata* has a green primary photobiont, whereas that of *P. perpetua* is blue-green. Morphological variation in lobe length has been used to separate *P. crocata* from *P. mougeotiana* in New Zealand (Galloway 1985). McCune and Geiser (1997) consider *P. mougeotiana* to b a synonym for *P. crocata*.

2. Reproductive Biology

P. perpetua reproduces asexually by soredia.

3. Ecological Roles

P. perpetua is a nitrogen-fixing cyanolichen and it contributes usable nitrogen to nutrient cycles in ecosystems where it occurs. Like other cyanolichens, it is probably sensitive to air pollution.

C. Range and Known Sites

So far, *P. perpetua* is known only from oceanic and suboceanic areas in North American and the Far East of Russia (Miadlikowska *et al*. 2001). In the Northwest Forest Plan area, it is known from three sites on the Oregon Coast. These are Gwynn Creek Special Interest Area (Siuslaw NF) near Cape Perpetua from which the type specimen was described, near Clear Lake about 23 km (14 mi) north of Florence; Eel Creek Campground (Oregon Dunes National Recreation Area); and Rock Creek, about 6.4 km (4 mi) north of Florence (Lane County). Two Hawaiian collections, in the Brigham Young University Herbarium, appear to be morphologically similar to *P. perpetua* (St. Clair, pers. comm.).

D. Habitat Characteristics and Species Abundance

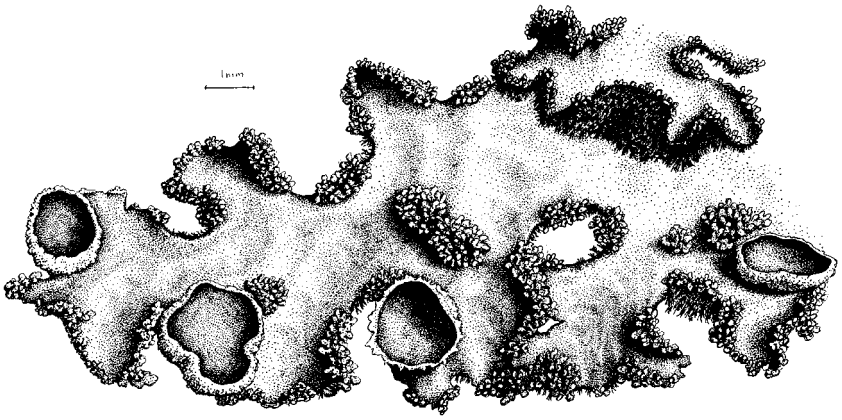

Figure 23. Drawing of *Pseudocyphellaria perpetua*.

P. perpetua occurs on both conifers and hardwoods. At Gwynn Creek it it was found on fallen conifer twigs and branches in a riparian old-growth Sitka spruce/Douglas-fir (*Pseudotsuga menziesii*) /western hemlock (*Tsuga heterophylla*) forest. At Eel creek it was found on dune forests of *Pinus contorta*, *Picea sitchensis*, *Arctostaphylos* and *Myrica california*. The closed *P. sitchensis* forest on the Oregon coast are often so dense that it grows only in the upper to mid-canopy and is most frequently encountered on fallen branches. This lichen is very rare, currently known globally from less than 10 locations.

II. CURRENT SPECIES SITUATION

A. Why Species Is Listed Under Survey and Manage Standard and Guidelines

P. perpetua was considered at risk under the Northwest Forest Plan because of its rarity and limited distribution in the range of the northern spotted owl. At the time of the FEMAT viability analysis, this lichen was known from only one site (USDA and USDI 1994a and 1994b).

B. Major Habitat and Viability Considerations

The major viability considerations for *P. perpetua* are loss of sites resulting from management activities that adversely affect the habitat area. Collecting voucher specimens may detrimentally affect this lichen which appears to be rare and of limited abundance.

C. Threats to the Species

Threats to *P. perpetua* are those actions that disrupt stand conditions necessary for its survival, including treatments that may impact sites, such as removing colonized or potentially suitable substrate, stand treatments that change micro-climatic conditions, or from recreational activity and development, or possibly degrading air quality. Because the lichen is currently known only from three sites in a habitat that is limited in extent due to past logging activities, fire history and land development, alteration of these areas may result in extirpation of the lichen. Collecting specimens may also have an adverse effect on the local population.

D. Distribution Relative to Land Allocations

One population of *P. perpetua* is in the Gwynn Creek Special Interest Area, and is in the proposed Cummins/Gwynn Research Natural Area. Land ownership and allocations for Clear Lake and Rock Creek sites are unknown at this time.

III. MANAGEMENT GOALS AND OBJECTIVES

A. Management Goals for the Taxon

The goal for managing *P. perpetua* is to assist in maintaining species viability.

B. Objectives

Manage all known sites on federal land by maintaining habitat, forest structure, occupied and potentially suitable substrate, and micro-climatic conditions associated with *P. perpetua*.

IV. HABITAT MANAGEMENT

A. Lessons From History

The taxonomic entity referred to as *P. perpetua* is currently thought to be a rare Pacific Northwest endemic whose taxonomy is poorly understood. Until the issues of taxonomic uncertainty are resolved, its history cannot be evaluated.

P. perpetua is a nitrogen-fixing lichen. For more than a century, lichen sensitivity to air pollution has been known, and many nitrogen-fixing species are especially sensitive to air pollution, particularly sulfur dioxide (Wetmore 1983). In the Pacific Northwest, lichens are currently being used as indicators of air quality on public lands (Geiser et al. 1994, Rhoades 1988, Ryan and Rhoades 1992, Stolte *et al*. 1993). In some parts of the Pacific Northwest, some nitrogen-fixing lichen species are beginning to decline and change morphologically from air quality degradation (Denison and Carpenter 1973, Geiser, pers. comm.).

B. Identifying Habitat Areas for Management

Known sites of *P. perpetua* on federal land administered by the Forest Service and BLM in the range of the Northwest Forest Plan are identified as areas where these management recommendations should be implemented. A habitat area for management is defined as suitable habitat occupied by or adjacent to a known population.

C. Managing in Habitat Areas

- Manage known sites to maintain suitable habitat for *P. perpetua* by allowing existing habitat conditions to persist and evolve naturally.
- Maintain existing habitat conditions until the taxonomic issues and rarity of the lichen are resolved.
- Collecting specimens of *P. perpetua* should be restricted to litterfall only; no material attached to its substrate should be collected.
- Specimens should be properly curated and deposited in an accredited herbarium.
- Activities such as prescribed burns and building new roads should be mitigated to minimize air pollution affects to the site.

D. Other Management Issues and Considerations

- The taxonomic uncertainty of this lichen is problematic. When the taxonomy is resolved, these management recommendations should be re-evaluated and updated to reflect appropriate action given the taxonomic status and relative rarity of this lichen.

- If sites are discovered on state and federals, work with appropriate State officials to exchange information and expertise, if requested.

V. RESEARCH, INVENTORY, AND MONITORING NEEDS

The objective of this section is to identify opportunities to acquire additional information which could contribute to more effective species management. The content of this section has not been prioritized or reviewed as to how important the particular items are for species management. The inventory, research, and monitoring identified below are not required. These recommendations should be addressed by a regional coordinating staff.

A. Data Gaps and Information Needs

- Revisit known sites to verify the status of the local populations, determine the extent and abundance of the population, and characterize ecological conditions.
- Evaluate distribution of populations, lichen abundance, and ecological requirements of *P. perpetua*, after taxonomic issues are resolved, to determine if this is still a lichen of concern.
- Determine if *P. perpetua* occurs in areas identified as potentially suitable habitat. Potential suitable habitat is identified as foggy coastal headlands with old-growth Sitka spruce, Douglas-fir, and western hemlock stands. Areas with potentially suitable habitat include Sutton Creek Recreation Area, Eel Creek Recreation Area and Sand Lake, Siuslaw NF; BLM Heceta Beach ACEC; BLM parcel adjacent to Cape Lookout, and other coastal BLM parcels.

B. Research Questions

- What is the taxonomic status of *P. perpetua*, and what is its relation to *P. crocata*?
- Does Hawaiian, Japanese and New Zealand material belong to the *P. perpetua* morphological group?
- Which habitat characteristics and ecological conditions are necessary for establishment of *P. perpetua* propagules and survival of established thalli?
- What are the rates of reproduction, dispersal and growth?
- What are the dispersal mechanisms and dispersal distances of *P. perpetua*?
- Is *P. perpetua* sensitive to air pollution?
- What is the genetic diversity within local populations and across the region?

C. Monitoring Needs and Recommendations

Monitor the known site at Gwynn Creek to document population trends and changes in habitat conditions.

Pseudocyphellaria rainierensis

SUMMARY

Species: *Pseudocyphellaria rainierensis* Imshaug
Taxonomic Group: Lichens (Rare Nitrogen-Fixing)
ROD Components: 1, 2, 3

Other Management Status: Oregon Natural Heritage Program List 3 (more information is needed before status can be determined, but which may be threatened or endangered in Oregon or throughout their range). Natural Heritage Network Ranks Oregon State Rank S2 (imperiled because of rarity or because other factors demonstrably make it very vulnerable to extirpation, typically with 6-20 occurrences). Global Rank G3 (Rare, uncommon or threatened, but not immediately imperiled, typically with 21-100 occurrences) (Oregon Natural Heritage Program 1998). BLM Bureau Tracking Status in Oregon (USDI, BLM 1998).

Range: *Pseudocyphellaria rainierensis* is endemic to the Pacific Northwest. It is found from southeastern Alaska, south to British Columbia, Washington, and Oregon. In the range of the northern spotted owl, it is reported from more than 40 sites, mostly on federal lands. It is reported in the Washington Cascades and Olympics, and the Oregon Cascades and Coast Range. It appears to reach the southern limit of its range in Douglas County on the Roseburg BLM District.

Specific Habitat: *P. rainierensis* is an epiphyte primarily on conifer trees in cool, humid, old-growth to climax forests in the Western Hemlock or lower Pacific Silver Fir Zones. The elevational range of known sites is between 100-1220 m (330-4000 ft). This species is rare in the range of the northern spotted owl. When present, *P. rainierensis* is generally not abundant, and occupies only a portion of what appears to be suitable habitat, suggesting strong dispersal limitations, and possibly specific habitat preferences.

Threats: The main threat to *P. rainierensis* is loss of populations resulting from activities that affect the habitat or the population, including changes in microclimate and removal of colonized substrate. As a nitrogen-fixing species, *P. rainierensis* may be sensitive to air pollution, as has been documented for other nitrogen-fixing lichens. *P. rainierensis* appears to be restricted to old forests. The limited distribution and abundance of these older age-classes in the landscape limit potentially suitable habitat, as well as contributing to the isolation of populations.

Management Recommendations:

- Manage populations at known sites by maintaining the ecological conditions associated with *P. rainierensis*, including old-growth forest structure, occupied and potentially suitable substrate and a cool, humid, interior forest microclimate. Restrict thinning or other stand treatments that will alter stand microclimate.
- Restrict collection of specimens where the species is rare or of limited abundance.

Information Needs: Determine the distribution of populations, species abundance, and ecological requirements of *P. rainierensis* in the area of the Northwest Forest Plan. Verify the current status of known populations.

I. NATURAL HISTORY

A. Taxonomy and Nomenclature

Pseudocyphellaria rainierensis Imshaug was first found in Mount Rainier National Park in 1948, and was described by Henry Imshaug in 1950 (Imshaug 1950). It is in the order Lecanorales, suborder Peltigeraceae, family Lobariaceae (Tehler 1996).

B. Species Description

1. Morphology and Chemistry

P. rainierensis is a large, blue-gray foliose lichen, with thallus lobes typically longer than wide. It bears a superficial resemblance to *L. oregana*, but the bluish-gray color of *P. rainierensis* and presence of pseudocyphellae (white spots) on the lower surface are distinctive features. *P. rainierensis* produces abundant lobules and/or isidia along the thallus margin, similar to those found in *L. oregana* (**Figure 24**).

Technical Description: Thallus foliose, large, loosely appressed to pendulous, 1-2 dm across, brittle when dry; lobes 0.5-3 cm broad; upper surface gray or pale bluish-gray, smooth or irregularly wrinkled; lower surface whitish to light brown, tomentose, with scattered conspicuous pseudocyphellae, 0.2-0.6 mm in size; primary photobiont a green alga, with internal cephalodia containing the cyanobacterium photobiont; lobules and coralloid isidia present; apothecia rare, reddish-brown, with thalline margin; medulla white to gray; cortex K+ yellow; medulla K- or brownish, all other spot tests negative (Imshaug 1950, McCune and Geiser 1997).

2. Reproductive Biology

P. rainierensis apparently reproduces primarily by producing asexual lobules and isidia, which break off the thallus and become established nearby. Because of the size of the lobules (0.5-3 mm), dispersal distances are probably typically short, limiting this species' dispersal capabilities. Only one fertile population is known (Sillett 1997, Sillett and Goward 1998), suggesting that apothecia are very rare and sexual reproduction is uncommon. The patchy distribution of *P. rainierensis*, even in suitable habitat, suggests there are factors limiting its dispersal and establishment (Sillett 1997, Sillett and Goward 1998, Goward 1994).

3. Ecological Roles

P. rainierensis is a nitrogen-fixing lichen. Nitrogen-fixing lichen species play an important ecological role by contributing nitrogen to ecosystems. Although *P. rainierensis* is generally restricted in its ecological distribution and generally not abundant when present, it provides a source of nitrogen in ecosystems where this nutrient is often limiting.

C. Range and Known Sites

P. rainierensis is endemic to the Pacific Northwest. It is found from southeastern Alaska south to British Columbia, Washington, and Oregon. It is only known west of the Cascade crest. In the range of the northern spotted owl it is reported from more than 40 sites, mostly on federal lands. It is reported from Washington in Whatcom, Snohomish, King, Pierce, Lewis, Skamania, Clallam, and Jefferson Counties. In Oregon, it is reported from Clackamas, Marion, Linn, Lane, Lincoln, Polk, and Douglas Counties. It appears to reach the southern limit of its range in Douglas County, Oregon.

P. rainierensis is documented from nine disjunct sites on the Mt. Baker-Snoqualmie NF (Whatcom, Snohomish, and King Counties), from the Nooksack River valley south to the Alpine Lakes Wilderness. Populations are reported from Mount Rainier National Park (Pierce County), including the type locality (Imshaug 1950). It is reported from four sites on the Olympic Peninsula in Clallam, Jefferson, and Grays Harbor Counties; these sites need to be verified. It is known from multiple sites on the Gifford Pinchot NF (Lewis and Skamania Counties), from the Cowlitz Valley Ranger District, and Mount St. Helens National Volcanic Monument south to the Mount Adams Ranger District.

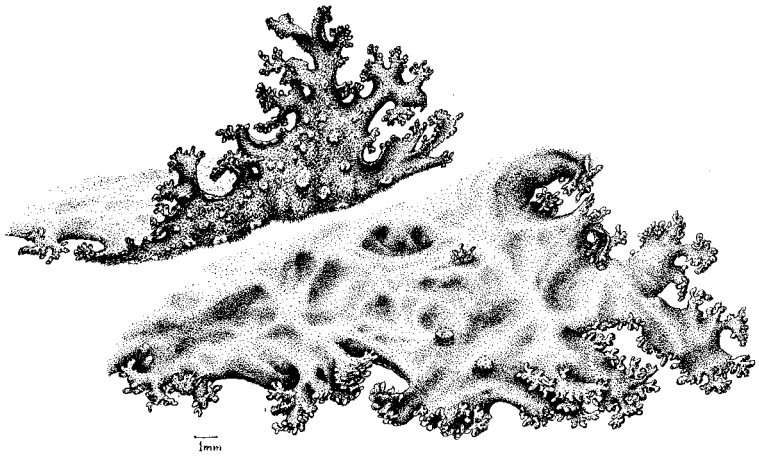

Figure 24. Drawing of the lobe tips of *Pseudocyphellaria rainierensis.*

In Oregon, it is known from the upper Sandy River, Estacada Ranger District, Mt. Hood and Bull of the Woods Wilderness areas on the Mt. Hood NF (Clackamas County); Salem District BLM in the Coast Range (Polk County), and Cascades (Linn County); and on the Willamette NF from the North Fork Santiam River area (Marion and Linn Counties), south to the H.J. Andrews Experimental Forest (Lane County). It is also known from the Oregon Coast at Cape Perpetua in Lincoln County (Sillett 1995). Based on current information, the southern limit of its range is on the Roseburg District BLM (Douglas County).

D. Habitat Characteristics and Species Abundance

P. rainierensis is a rare species throughout the range of the northern spotted owl. It appears there are factors that limit the dispersal and establishment of this lichen, as it is often absent from sites that appear to be suitable habitat. When present, *P. rainierensis* is not abundant; within stands it typically has a patchy distribution and is absent on apparently suitable substrate. *P. rainierensis* is very limited in distribution and appears to be restricted to old-growth and climax forests.

P. rainierensis is an epiphyte primarily on conifer trees in old-growth forests in the Western Hemlock or lower Pacific Silver Fir zones. It has been reported as an epiphyte on Pacific silver fir (*Abies amabilis*), Douglas-fir (*Pseudotsuga menziesii*), western hemlock (*Tsuga heterophylla*), subalpine fir (*Abies lasiocarpa*), Pacific yew (*Taxus brevifolia*), Sitka spruce (*Picea sitchensis*), and western redcedar (*Thuja plicata*), as well as bigleaf maple (*Acer macrophyllum*), vine maple (*Acer circinatum*), red alder (*Alnus rubra*), cascara (*Rhamnus purshiana*), chinquapin (*Chrysolepis chrysophylla*), black cottonwood (*Populus trichocarpa*), and Pacific rhododendron (*Rhododendron macrophyllum*). The elevational range of known sites is from 100-1220 m (330-4000 ft). The common feature of the habitats at known sites appears to be old-growth forest structure with cool, humid microclimate.

In the North Cascades of Washington on the Mt. Baker-Snoqualmie NF, the typical habitat of *P. rainierensis* is mesic to moist, old-growth Pacific Silver Fir/Alaska Huckleberry (*Vaccinium alaskaense*) forests more than 500 years old. Generally, these sites are in wet climatic areas with high precipitation, and the forests are characterized by high humidity and cool temperatures. In these areas, *P. rainierensis* is an epiphyte on the lower boles of Pacific silver fir. Other habitats where this species has been documented in northern Washington include an old-growth Douglas-fir/western hemlock forest, and an

unusual low elevation stand of dead or dying subalpine fir on the Sulphur Creek lava flow (Rhoades 1981).

In the southern Washington Cascades on the Gifford Pinchot NF, *P. rainierensis* grows in old-growth Douglas-fir/western hemlock forests, with western redcedar and Pacific yew sometimes present. In this area, it has been recorded as an epiphyte on Douglas-fir, western hemlock, Pacific silver fir, bigleaf maple, and vine maple.

In Oregon, the majority of known sites are in old-growth conifer forests. Typical habitat for *P. rainierensis* is old-growth Douglas-fir/western hemlock forests from 490-900 m (1600-2950 ft) elevation. It has been recorded as an epiphyte on Douglas-fir, western hemlock, Pacific silver fir, Pacific yew, western redcedar, Sitka spruce, red alder, chinquapin, and in canopy litterfall. In Oregon, it may not be restricted entirely to interior forest; it has persisted on an old-growth Douglas-fir at the edge of a 20-year-old clear-cut (Sillett 1995), and was found on an open grown western hemlock on a talus slope in an old-growth Douglas-fir/western hemlock forest. This lichen species has also been found on the moss-covered branches of Pacific yew in partially open conditions under the shelter of an old-growth forest canopy.

P. rainierensis appears to be one of the last lichens to reach the upper canopy during forest development (McCune 1993, Sillett 1995, Sillett and Neitlich 1996). In the 700-year-old Douglas-fir trees it was limited to the middle and lower crown (Sillett 1995), with a distribution pattern similar to the moss, *Antitrichia curtipendula*. These moss mats may provide an important function in regulating moisture regimes in the forest canopy (Norris, pers. comm., Sillett 1995), and may contribute to providing suitable habitat and micro-climatic conditions for *P. rainierensis*.

Several reports of *P. rainierensis* are from stands younger than 200 years (Sillett 1995, Messinger pers. comm.). These sites are in the western Oregon Cascades and described as mature forests, late-successional forests, and a 140-year-old riparian forest of Douglas-fir and western hemlock.

II. CURRENT SPECIES SITUATION

A. Why Species is Listed Under the Survey and Manage Standard and Guideline

P. rainierensis was considered at risk under the Northwest Forest Plan because of its rarity and limited distribution in the range of the northern spotted owl (USDA and USDI 1994a, 1994b). At the time of the lichen viability panel, it was known from 16 sites in the range of the northern spotted owl (USDA and USDI 1994a, 1994b). This species is endemic to the Pacific Northwest and reaches its southern limit in Oregon. Based on current information, it is closely associated with old-growth forests. In addition, it is assumed to be sensitive to air pollution, as inferred from the known sensitivity of other nitrogen-fixing lichen species (Rose 1988). Because of its rarity, its close association with old-growth forests, and its presumed dispersal limitation, *P. rainierensis* is potentially vulnerable to land management activities, and there was a high level of concern for species persistence. Because of these concerns, *P. rainierensis* was listed under the Survey and Manage strategies 1,2 and 3 to manage known sites, to locate additional populations on federal lands, and to identify high priority sites for management (USDA and USDI 1994c).

B. Major Habitat and Viability Considerations

The close association of *P. rainierensis* with old forests in certain climatic regimes in the Pacific Northwest is an important factor determining this species' distribution. This association indicates specific ecological requirements, and may reflect the inability of this species to become established or maintain viable populations in younger forests. The limited extent of older age-classes across the landscape, particularly in certain geographical areas, suggests that potential suitable habitat may be limited for this

species. This contributes to the isolation of populations and the vulnerability of populations to disturbance. The major viability consideration for *P. rainierensis* is loss of populations resulting from management activities that affect populations or their habitat.

It appears there are factors that limit the dispersal and establishment of this lichen. *P. rainierensis* is often absent from sites that appear to be suitable habitat. Even when this species occurs, it is patchy in its distribution and is absent on apparently suitable substrate.

A warming climate may stress populations at the limits of a species' range, and could result in a decline in vigor and a more restricted distribution of *P. rainierensis.*

C. Threats to the Species

Threats to *P. rainierensis* are those actions that disrupt stand conditions necessary for its survival, including treatments that may directly or indirectly affect populations, such as removing colonized or potential substrate, stand treatments that result in changes in forest structure or changes in microclimate (such as temperature, humidity, radiation). Significant deterioration in air quality is also a potential threat to this species.

D. Distribution Relative to Land Allocations

The distribution of known sites of *P. rainierensis* relative to land allocations needs to be determined. Each administrative unit should evaluate the land allocations for known sites on lands within its jurisdiction, and share this information at the regional level.

III. MANAGEMENT GOAL AND OBJECTIVES

A. Management Goal for the Species

The goal for managing *P. rainierensis* is to assist in maintaining species viability.

B. Objectives

Manage known sites on federal lands by maintaining habitat, forest structure, occupied and potential suitable substrate, and micro-climatic conditions associated with *P. rainierensis.*

IV. HABITAT MANAGEMENT

A. Lessons From History

Lichen species with specific ecological requirements may experience population declines in response to land management activities that affect habitat or decrease potential or occupied habitats. Loss of species richness has been documented in areas of Europe in response to land management practices (Rose 1988, Olsen and Gauslaa 1991, Esseen *et al*. 1992). There has been little documentation of *P. rainierensis* in response to management treatments or other disturbance in the Pacific Northwest. It was probably more abundant in the past, since some of its probable habitat and substrate has been removed through timber harvest activities.

The thalli of *P. rainierensis* may need time to become acclimatized to edge conditions when populations are isolated by harvesting (Sillett 1994). Sillett conducted transplant studies of *P. rainierensis* thalli that originated from edge and old-growth interior forest sites. His results showed that edge lichens

transplanted back to a 20-year-old regeneration clear-cut edge environment grew well, but interior lichens from a 700-year-old stand transplanted to the clear-cut edge lost weight (Sillett 1994). This study suggests that maintaining interior forest habitat conditions around *P. rainierensis* populations adjacent to timber harvest or road building activities may be important.

Many lichen species are known to be sensitive to air pollution, and lichen population declines attributed to air pollution have been documented in Europe and North America (Rao and LeBlanc 1967, Skye and Hallberg 1969, Hawksworth 1971, Ferry et al. 1973, Hawksworth and Rose 1976, Case 1980, Sigal and Nash 1983, Gilbert 1992). Many nitrogen-fixing lichen species are especially sensitive to air pollution, particularly sulfur dioxide (Wetmore 1983). The air pollution sensitivity of *P. rainierensis* is unknown, but it is likely to be sensitive to pollution, based on the known sensitivity of other nitrogen-fixing lichen species.

B. Identifying Habitat Areas for Management

All known sites of *P. rainierensis* on federal lands administered by the Forest Service and BLM in the range of the northern spotted owl are identified as habitat areas where these management recommendations apply. A habitat area for management is defined as suitable habitat occupied by or adjacent to a known population.

C. Managing in Habitat Areas

- Determine the extent of the local population and habitat area with a field visit.
- Habitat areas should be managed to include an area large enough to maintain the ecological conditions associated with *P. rainierensis*, including undisturbed forest structure and interior forest micro-climatic conditions.
- At all locations, current habitat conditions should be maintained, and allowed to develop naturally. The size of the area necessary to maintain populations and interior forest conditions should be determined by a field visit.
- Maintain occupied substrate and manage a habitat area large enough to provide for a distribution of appropriate substrate within the habitat area.
- Restrict thinning or other stand treatments that will alter stand microclimate.
- Prevent fire in habitat areas with emphasis on fire suppression.
- Restrict collection of specimens in areas where this species is rare or of limited abundance.

D. Other Management Issues and Considerations

- Providing a well-distributed network of older forests in the range of *P. rainierensis* will provide stands to replace those lost to fire, blowdown, or other natural disturbance events.
- Target the older stands in watersheds to meet the Standard and Guideline for 15% retention of old-growth in watersheds where little remains. Maintaining the older age classes across the landscape is important for *P. rainierensis* as this lichen typically does not occur in younger-aged late-successional forests.
- *P. rainierensis* should be evaluated for its sensitivity to air pollutants. As a nitrogen-fixing lichen, it is thought to be very sensitive to air pollution.

V. RESEARCH, INVENTORY, AND MONITORING NEEDS

The objective of this section is to identify opportunities to acquire additional information that could contribute to more effective species management. The content of this section has not been prioritized or reviewed as to how important the particular items are for species management. The inventory, research, and monitoring identified below are not required. These recommendations should be addressed by a

regional coordinating staff.

A. Data Gaps and Information Needs

- Revisit known sites to verify the status of known populations, determine the extent of populations and abundance, and characterize ecological conditions.
- Request additional information from S. Sillett, K. Glew and G. McHenry-Teller to incorporate their reported sites of *P. rainierensis* into the regional interagency species database.
- Locate and determine the status of reported populations on the Olympic Peninsula.
- Prioritize Strategy 3 surveys in areas where projects are scheduled or proposed.
- Determine the distribution of *P. rainierensis* in areas identified as potential suitable habitat. Potential suitable habitat is characterized as old-growth to climax forests in high precipitation areas of the Western Hemlock and Pacific Silver Fir zones, with cool humid microclimate.
- Determine the air pollution sensitivity of *P. rainierensis.*
- Revisit the 140-year-old riparian site in the Blue River basin, and other sites in stands less than 200 years old on the Willamette NF, and characterize habitat conditions and forest structure to compare with the ecological conditions at other sites.

B. Research Questions

- What habitat characteristics and ecological conditions are necessary for establishment of *P. rainierensis* propagules and survival of established thalli?
- What are the dispersal mechanisms and dispersal distances of *P. rainierensis* propagules?
- What limits dispersal and establishment of propagules and colonization of suitable habitat?
- What are the rates of growth and reproduction for this species?
- What is the genetic diversity of this species within its local populations and across the region?
- Can other locations be found where populations of *P. rainierensis* have persisted after harvest treatments, as reported by Sillett (1994, 1995)?
- Is *P. rainierensis* sensitive to air pollution?

C. Monitoring Needs and Recommendations

- If management activities occur near known sites, monitor the population to determine its response to treatment and the effects on the population.
- Establish monitoring plots in the population of *P. rainierensis* in the recent blowdown area of the Sauk River on the Mt. Baker-Snoqualmie NF to document population trends of *P. rainierensis* in response to this disturbance.
- Consider establishing air quality monitoring plots near selected known populations.

Pseudocyphellaria rainierensis

Pyrrhospora quernea

SUMMARY

Species: *Pyrrhospora quernea* (Dickson) Körber
Taxonomic Group: Lichens (Oceanic-Influenced)
ROD Components: 1, 3

Other Management Status: None

Range: In the range of the Northwest Forest Plan, *Pyrrhospora quernea* is known from only four sites on federal land, two administered by the Siuslaw NF at the mouth of Gwynn Creek in the Cape Perpetua Special Interest Area, and at Horsefall Campground, Oregon Dunes National Recreation Area; and Lanphere Dunes Unit (Humboldt Bay National Wildlife Refuge, USFWS). Other Oregon sites are Cape Blanco State Park, and private land near the Newport Beach Nelson Wayside. In Washington, it is also found at the Sequim Cemetery, and on San Juan Island and Fidalgo Island. The other California sites are Hookton Road, and Patricks Point State Park. In more southerly coastal areas of California, especially the Channel Islands, *P. quernea* is considered common.

Specific Habitat: In the Pacific Northwest, *P. quernea* grows in hypermaritime habitats within a few kilometers of the Pacific Ocean, including near estuaries, on stabilized dunes, and rocky coastal headlands. Its known substrates are Sitka spruce and shore pine in old-growth stands. It also grows on oaks, alder, elderberry and other coastal shrubs, and on old board fences and other wood. In Europe, it grows on moderately nutrient-rich rough bark, particularly of oaks, and occasionally on wood or even sandstone.

Threats: The major threat to *P. quernea* is loss of populations from activities that adversely affect the habitat or the population, such as altering microclimate and removing colonized substrate. Because *P. quernea* is known from three sites on federal lands in the range of the Northwest Forest Plan, altering them could result in local extirpation of the species. Climate change that alters conditions necessary for its survival may result in a decline in vigor of the species, or may be a factor in causing local extirpation.

Management Recommendations:
- Manage known sites to maintain local populations and their habitat areas.
- Develop practices to route human use away from known sites.
- Manage fire in habitat areas, with emphasis on prevention near occupied substrates.
- Restrict removal of trees, shrubs, or other vegetation from known sites and habitat areas, except when removal will not harm habitat integrity.

Information Needs:
- Visit known sites to describe the geographical extent of local populations, and improve habitat descriptions.
- Determine if *P. quernea* is closely associated with late-successional or old-growth forest.
- Determine whether additional populations exist in areas identified as potential suitable habitat.

Pyrrhospora quernea

I. NATURAL HISTORY

A. Taxonomy and Nomenclature

Pyrrhospora quernea (Dickson) Körber (1855)

Synonyms:
Protoblastenia quernea (Dickson) Clauzade
Lecidea quernea (Dickson) Acharius

P. quernea is a lichenized Ascomycete in the family Lecanoraceae, order Lecanorales (Tehler 1996). The genus is closely related to *Lecidella*, and is included in the Lecanoraceae on the basis of ascus structure but it lacks a thalline exciple (Purvis et al. 1992).

B. Species Description

1. Morphology and Chemistry

P. quernea (**Figure 25**) is a crustose lichen characterized by a thallus thickly farinose to granular-sorediate, granules to about 150 µm in diameter, arising over the surface of the thallus, even, often indistinctly areolate, yellowish or greenish-fawn; prothallus generally present, forming a delimiting black line to 250 µm wide. Apothecia are 0.4-1(1.5) mm diameter, strongly convex, often irregular in shape, dark reddish-brown; true exciple excluded; epithecium interspersed with reddish brown granules, K+ dissolving, purplish. Ascospores are (7) 8-12 (14) x (5) 6-7 (8) µm. Thallus PD- or weakly yellowish, K-, KC+ orange, C+ orange, UV- or blackish orange (isoarthothelin, thiophanic acid and ± trihydroxy-2-chloro-6-methylanthraquinone). Apothecia are K+ reddish-purple in section, containing 1,3,8-trihydroxy-2-chloro-6-methylanthraquinone (Purvis et al. 1992:523).

2. Reproductive Biology

P. quernea reproduces vegetatively by producing soredia, microscopic clusters of algal cells and fungal filaments, that can initiate a new thallus if habitat conditions are suitable. The microscopic size of the reproductive propagules should allow them to be carried long distances by wind, animals, or birds. Birds in particular are thought to enhance arrival rates of rare oceanic species by dispersing lichen propagules along coastal migratory routes of the Pacific Northwest (McCune et al. 1997).

P. quernea also reproduces sexually by producing fungal ascospores. The fungal spores germinate and presumably reunite with the appropriate green algal photobiont, forming a new lichen thallus. This means of reproduction is generally considered slow compared to asexual propagation.

3. Ecological Roles

Little to nothing is known of the ecological roles of *P. quernea*. Crustose lichens in the Pacific Northwest commonly show signs of feeding by invertebrates. Various molluscs and insects (e.g., bristletails, barklice, katydids, grasshoppers, webspinners, butterflies, moths, lacewing larvae, mites, spiders, snails, slugs, and many beetles) live on or mimic lichens, or graze upon the algal rich layer and reproductive structures (Gerson and Seaward 1977).

C. Range and Known Sites

P. quernea is found in North America, Europe, and Micronesia (Purvis et al. 1992). In North America, it is reported from scattered locations in Minnesota, Montana, California (Fink 1935), and the Pacific

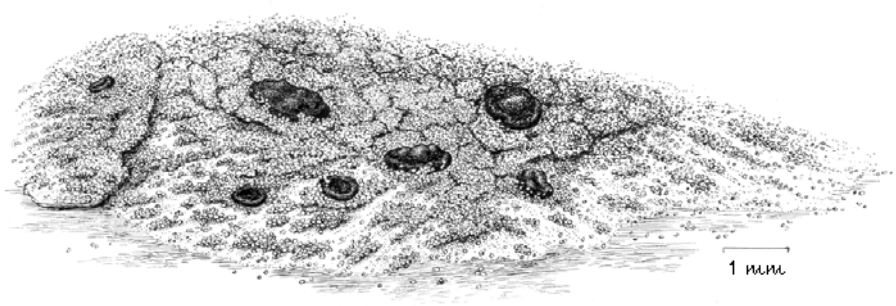

Figure 25. Drawing of *Pyrrhospora quernea.*

Northwest. In the range of the Northwest Forest Plan, *P. quernea* is found at four sites on federal land, two administered by the Siuslaw NF, one by US Fish and Wildlife Service. The Siuslaw NF sites are at the mouth of Gwynn Creek in the Cape Perpetua Special Interest Area (Lincoln County), and Horsefall Campground parking lot, 1 km (0.6 mi) north of North Bend, in the Oregon Dunes National Recreation Area (Coos County). The USFWS site is Lanphere Dunes Unit (Humboldt Bay National Wildlife Refuge, Humboldt County) on the Samoa Peninsula. Two other Oregon sites are at Cape Blanco State Park (Curry County) and a parcel of private land near the Newport Beach Nelson Wayside. In Washington, it is also found at the Sequim Cemetery (Clallam County), on San Juan Island (San Juan County), and Fidalgo Island (Skagit County). Other California sites in the range of the Northwest Forest Plan Hookton Road (Humboldt County), and Patricks Point State Park (Humboldt County). In more southerly coastal areas of California, especially the Channel Islands, *P. quernea* is considered common.

D. Habitat Characteristics and Species Abundance

In the Pacific Northwest, *P. quernea* occurs in hypermaritime habitats within a few kilometers of the Pacific Ocean, including estuaries, stabilized dunes, and rocky coastal headlands. Its known substrates are Sitka spruce (*Picea sitchensis*), and shore pine (*Pinus contorta*) in old-growth stands. It also grows on oaks (*Quercus* spp.), alder (*Alnus*), elderberry (*Sambucus*), and other coastal shrubs, and on old board fences and other wood. In Europe, it grows on moderately nutrient-rich rough bark, particularly on oaks and occasionally on wood or sandstone (Purvis et al. 1992).

II. CURRENT SPECIES SITUATION

A. Why Species Is Listed Under Survey and Manage Standard and Guideline

P. quernea was considered at risk under the Northwest Forest Plan because of its rarity and limited distribution in the range of the northern spotted owl (USDA and USDI 1994a, 1994b). At the time, it was known from four populations in the range of the northern spotted owl (USDA and USDI 1994b).

Because of persistence concerns, this species was identified as a Survey and Manage Strategy 1 and 3 species (USDA and USDI 1994c), with the dual objectives of managing known sites and conducting extensive surveys to locate additional populations and identify other high-priority sites for species management.

B. Major Habitat and Viability Considerations

Frequent fog along the coast, combined with moderate temperatures, create a suitable environment for ocean-influenced lichens like *P. quernea*. The broken topography, natural firebreaks, and ocean spray all act to reduce the influence of fire on the immediate coast, and migrating birds may enhance arrival rates by spreading lichen propagules. High species diversity, successful colonization by rare oceanic species, and reduced rates of population extirpations are natural features of immediate coastal habitats (McCune et al. 1997).

The major habitat and viability concerns for *P. quernea* are the small number of populations, the limited amount of suitable habitat for this species on federal land, and loss of populations from management activities that adversely affect the remaining habitat or populations. Much of the low elevation coastal forest land in the Pacific Northwest is under non-federal ownership and, along the immediate coast, development pressures are increasing. Outside of urban areas, privately owned forests are generally managed on short harvest rotations. Given that lichens are slow to establish in rapidly growing stands and do not become abundant until late in successional development (USDA and USDI 1994a), most of these stands are harvested before lichens have a chance to re-establish significant populations.

C. Threats to the Species

Threats to *P. quernea* are those actions that disrupt stand conditions necessary for its survival. Such actions include treatments that reduce local populations by removing colonized bark or wood substrates; decreasing exposure to light; adversely affecting integrity of habitat areas; reducing or fragmenting potential habitat; or degrading air quality.

Recreational activities and developments may inadvertently alter the habitat of this species. Trampling by recreational vehicles and frequent foot traffic are serious threats, especially in shore pine woodlands and edge communities, as these degrade the habitat by disturbing fragile root systems of trees and shrubs, and the fragile protective mats of ground lichens, which stabilize the soil (Christy et al. 1998). Destabilization of the foredunes by recreationists or removal of European beachgrass (*Ammophila arenaria*) can destabilize tree island habitats of *P. quernea* by increasing the amount of sand drift into them and burying trees on the perimeter (Christy et al. 1998). Buildings, roads, campgrounds and trails along the immediate coast have replaced many natural habitats to improve access, facilitate scenic views, or develop recreational uses.

Other threats to the integrity of habitat and potential habitat areas include logging, grazing, agriculture, and activities which alter local hydrology, or increase fire frequency (Christy et al. 1998). Concern about fire varies—many different plant communities and successional stages exist among the coastal dunes and headlands; fire is beneficial to some communities but damaging to others. Invasion or planting of exotics such as Scots broom (*Cytisus scoparium*), European beachgrass, tree lupine (*Lupinus arboreus*), birdsfoot-trefoil (*Lotus corniculatus*), and iceplant (*Mesembryanthemum* spp.) can have profound effects on nitrogen-poor dune soils by increasing nitrogen and soil moisture. These conditions foster invasion of other weeds, eventually disrupting native plant communities (Christy et al. 1998) and reducing plant and animal diversity (USDI 1997).

The air-pollution sensitivity of *P. quernea* is unknown, but crustose species are typically more tolerant of air pollution than other lichen forms. Because the primary habitat of this lichen is the coastal fog belt, and because fog significantly concentrates pollutants, especially acidic forms of SO_x and NO_x to which lichens are most sensitive, the potential vulnerability of *P. quernea* to air-quality deterioration may be a reasonable concern. Although air quality is relatively good at known sites, rising pollution emissions from increased traffic (mainly NO_x) and new or expanded industry (SO_x and NO_x) along the coast could threaten this species in the future.

Climate change affecting coastal fog patterns could affect the vigor of this species, possibly restricting distribution or contributing to local extirpation.

Isolation of populations also leads to genetic isolation. Almost nothing is known about the genetics of lichen populations or the effects of gene pool isolation on local extinction rates of populations.

D. Distribution Relative to Land Allocations

Two populations of *P. quernea* on federal land are administered by the Siuslaw NF. The population at Horsefall Creek in the Oregon Dunes National Recreation Area, which is Congressionally withdrawn. The population at Gywnn Creek is inside the Cape Perpetua Special Interest Area, also congressionally withdrawn. Lanphere Dunes Unit is part of the Humboldt Bay National Wildlife Refuge (USDI 1997).

III. MANAGEMENT GOAL AND OBJECTIVES

A. Management Goal for the Species

The goal for managing *P. quernea* is to assist in maintaining species viability.

B. Objectives

Manage populations at all known sites on federal lands by maintaining habitat and potential habitat immediately surrounding known populations.

IV. HABITAT MANAGEMENT

A. Lessons From History

Habitat destruction or alteration has made a significant contribution to the decline of lichens world-wide (Seaward 1977). Rare lichens, that occur in habitats optimal for human activities, such as the immediate coast, are especially vulnerable. In coastal Oregon, activities of the past 140 years including increased logging, recreation agriculture and grazing, fire, and changes in hydrology have significantly altered plant succession (Christy et al. 1998). For example, at Sand Lake dunes of Oregon, an area of high lichen diversity, off-road vehicles have destroyed nearly all the fragile shore pine woodland habitat in just thirty years (Wiedemann 1984, 1990 as cited by Christy et al. 1998).

Lichens have been known to be sensitive to air pollution more than a century. Lichens that obtain most of their water from fog and dew are particularly vulnerable to air quality and weather patterns (Nash 1996). Follmann (1995) documented massive impoverishment and retrogression of lichens over much of the northern Chilean coastal fog belt during the past 20 years. Increasing frequency of El Niño events and gradually increasing aridity were postulated as likely, but not exclusive, factors causing this decline. Populations of many species in Europe (Hawksworth and Rose 1976) and eastern United States have declined precipitously from exposure to sulfur dioxide and other air pollutants. In the United States, lichens are one of the components used to indicate stress to forests from air pollution (McCune et al. 1996). In the Pacific Northwest, sensitive species are already declining in some areas (Denison and Carpenter 1973, Taylor and Bell 1983) and lichens are identified as Air Quality Related Values in USDA Forest Service regional guidelines (Peterson et al. 1992).

B. Identifying Habitat Areas for Management

All known sites of *P. quernea* on federal land administered by the Forest Service or BLM in the range of the Northwest Forest Plan are identified as areas where these management recommendations should be implemented. A habitat area for management is defined as suitable habitat occupied by or near a known population.

C. Managing in Habitat Areas

The objective of managing in habitat areas is to maintain habitat conditions for *P. quernea*. Specific conditions for *P. quernea* are the foggy coastal headlands with old-growth Sitka spruce, shore pine, oak, elderberry, and old wood (such as wooden fence posts and old buildings).

- Determine the extent of the local population and habitat area with a site visit.
- Maintain suitable habitat around the current host trees and shrubs, so that the lichen may have adequate new substrate as current substrates decline.
- Develop practices to route human use away from the populations in habitats areas (e.g., divert roads, trails and off-road vehicles). Trampling shrubs or ground lichens, compacting roots, damaging trees or branches that serve as substrates, introducing non-native species by seed dispersal or planting, can all adversely affect habitat integrity.
- Avoid harvesting trees, shrubs, or other vegetation from the population and the habitat area unless these actions would do no harm to, or would improve, the habitat for *P. quernea* (e.g., by preventing deeply shaded conditions or by removing invasive exotics).
- Prevent fire in the population but utilize or prevent fire in the habitat areas, depending on the role of fire in the plant community. Consider recommendations by Christy et al. (1998) for fire management in coastal plant communities.

D. Other Management Issues and Considerations

- Consider opportunities for managing known sites during Forest Plan and Resource Management Plan revisions, such as Botanical Special Interest Areas, Areas of Critical Environmental Concern, or other administratively withdrawn designations, or by prescribing special standards and guidelines.
- Share information with State and private sectors to further activities directed at conserving *P. quernea.*

V. RESEARCH, INVENTORY, AND MONITORING NEEDS

The objective of this section is to identify opportunities to acquire additional information that could contribute to more effective species management. The content of this section has not been prioritized or reviewed as to how important the particular items are for species management. The inventory, research, and monitoring identified below are not required. These recommendations should be addressed by a regional coordinating staff.

A. Data Gaps and Information Needs

- Visit known sites to determine the extent of local populations, and improve habitat descriptions.
- Determine if *P. quernea* meets the criteria for being closely associated with late-successional or old-growth forests.
- Determine whether additional populations exist in areas identified as potential suitable habitat.

B. Research Questions

- What are the dispersal rates and mechanisms of *P. quernea*?
- Which habitat and micro-climate characteristics are necessary for establishing *P. quernea* thallus fragments and survival of established thalli?
- What is the genetic diversity of *P. quernea* within local populations and across the region?
- What is the air pollution sensitivity of *P. quern*ea?

- What are the minimum and optimum patch sizes of colonized habitat necessary to provide for *P. quernea*?

C. Monitoring Needs and Recommendations

- Monitor known sites for changes in micro-climatic conditions, successional changes, and for inadvertent habitat damage from human activities or wildfire.
- Monitor dispersal and population trends of existing populations.

Pyrrhospora quernea

Sticta arctica

SUMMARY

Species: *Sticta arctica* Degel.
Taxonomic Group: Lichens (Rare Rock)
ROD Components: 1, 3

Other Management Status: The Nature Conservancy Oregon State Rank S1 (critically imperiled because of extreme rarity or because it is somehow especially vulnerable to extinction or extirpation, typically with 5 or fewer occurrences). The Nature Conservancy Global Rank G5 (demonstrably widespread, abundant, and secure). Oregon Natural Heritage Program List 2 (threatened with extirpation or presumed to be extirpated from the State of Oregon) (Oregon Natural Heritage Program 1998). BLM Bureau Assessment Status in Oregon (USDI Bureau of Land Management 1998).

Range: *Sticta arctica* is known from Siberia, Kamchatka, and North America. Until recently its North American range only extended as far south as Juneau, Alaska. In the range of the Northwest Forest Plan there are two disjunct populations, neither on federal lands; Deception Pass State Park on Whidbey Island, Washington, and Saddle Mountain State Park, Oregon.

Specific Habitat: *S. arctica* is an arctic-alpine lichen that grows among mosses and on hummocks in dry and moist tundra in the northern part of its range. In its southern range, it is found on rocky ledges and mossy soil near the edges of marine beaches, and on a moss-covered basalt outcrop on a rocky mountain summit at 900 m (2950 ft) near the coast. It can be easily overlooked because it is small and grows intermingled with other species.

Threats: The major threat to *S. arctica* is loss of local populations resulting from activities that affect the population or its habitat, including collecting specimens, removing colonized substrate, and alter its microclimate. Because it is not yet known from old-growth and is found on coastal rocks and soil or on coastal mountain summits, recreation-related activities such as hiking, mountain biking, trail or shelter building would be most likely to threaten the species.

Management Recommendations:

- Maintain existing habitat conditions, including occupied substrate and associated micro-climatic conditions, and restrict collecting of specimens, at any sites discovered on lands administered by the Forest Service or BLM.

Information Needs:

- Determine if *S. arctica* meets the criteria for close association with late-successional or old-growth forests.
- Determine distribution of local populations, species abundance and ecological requirements of *S. arctica* in the range of the Northwest Forest Plan on federal lands.

Sticta arctica

I. NATURAL HISTORY

A. Taxonomy and Nomenclature

Sticta arctica Degel. was described by Degelius in 1937 (in Medd. Goteborgs Bot. Tradg. 12:108).

B. Species Description

1. Morphology and Chemistry

S. arctica is a small, dark brown foliose lichen with scattered cyphellae on the lower surface (**Figure 26**). These cyphellae are large, white, circular, recessed pores that resemble lunar craters. The upper side is smooth with somewhat crisped edges, the underside is pale at the edges, dark toward the center, and covered with a fine tomentum (woolly or felt-like hairs).

Technical Description: Thallus foliose, dorsiventral, the lobes small, to 30 mm long and 12 mm broad, the edges somewhat crisped and turned up, upper surface paraplectenchymous, smooth, brown; underside pale at the edges, dark centrally, covered with a fine tomentum and with scattered cyphellae, attached to substrate by simple or branched rhizines. Apothecia and pycnidia are not known. Cyanobacterium is *Nostoc* (Thomson 1984:432). Chemistry: K-, C-, KC-, PD-, I-.

2. Reproductive Biology

Sexual reproductive structures are unknown for *S. arctica*. It reproduces asexually by producing lobules; migrating arctic birds may be a vector for distributing lobules (McCune et al. 1997). This species also reproduces by fragmentation when thalli are broken apart by animals or disrupted by rolling rocks or wind, and pieces become re-established nearby.

3. Ecological Roles

Very little is known about the ecological roles of this species in the Pacific Northwest. It appears to have a geographic affinity with northeastern Asia and the maritime Arctic (McCune et al. 1997), and may have ecological ties with associated northeastern Asia and maritime Arctic plant and animal communities and habitats. The widely disjunct sites in Washington and Oregon may be relicts from a previous, colder climatic period.

C. Range and Known Sites

S. arctica is known from Siberia, Kamchatka, and North America (Krog 1968). Until 1993, its North America distribution was known to extend from arctic Alaska east to Baffin Island, Canada, and as far south as Juneau, Alaska (Krog 1968).

In 1993, a single disjunct site was found near the summit of Saddle Mountain State Park in Clatsop County, Oregon (*Derr #881*), extending its range over 1000 km (600 miles) to the south (McCune et al. 1997). Recent herbaria searches provided information on two additional southern populations of *S. arctica*, one from the Queen Charlotte Islands, British Columbia, and one from Deception Pass State Park, Washington; they had been misidentified as *S. weigelii* (McCune et al. 1997). Only two sites are in the range of the Northwest Forest Plan: at Deception Pass State Park, Whidbey Island, Island County, Washington, and Saddle Mountain State Park, Clatsop County, Oregon. *S. arctica* is rare in the range of the Northwest Forest Plan, known from only two sites. *S. arctica* is not known to occur on federal land.

D. Habitat Characteristics and Species Abundance

S. arctica is an arctic-alpine species that grows among mosses and on hummocks in both dry and moist tundras in the northern part of its range (Thomson 1984). In British Columbia and Washington, it is known from rocky ledges, soil and rock at the edge of marine beaches (McCune et al. 1997). In Oregon, it is only known from a massive moss-covered basalt outcrop on the windswept ridge of an exposed rocky mountain summit of Saddle Mountain (elevation about 900 m (2950 ft)) near the coast, where only a few thalli were present (McCune et al. 1997). It can easily be overlooked because it is small and grows intermingled with bryophytes.

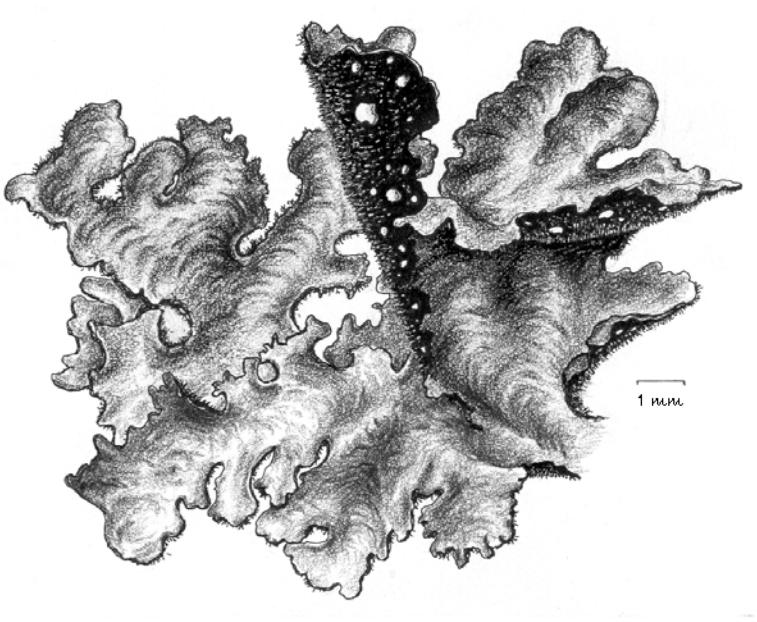

Figure 26. Drawing of *Sticta arctica.*

II. CURRENT SPECIES SITUATION

A. Why Species Is Listed Under Survey and Manage Standard and Guideline

S. arctica was considered at risk under the Northwest Forest Plan because of its presumed rarity in the range of the northern spotted owl, known from only one disjunct population (USDA and USDI 1994a,b). The concern for this species is still high, as there are only two known sites in the range of the northern spotted owl, and neither of these populations are on federal land.

B. Major Habitat and Viability Considerations

The major viability considerations for *S. arctica* are loss of local populations resulting from collecting specimens that could extirpate local populations, and management activities that adversely affect the individuals or their habitat. A warming climate may stress populations at the limits of a species range and could result in a decline in vigor and a more restricted distribution of *S. arctica*. If *S. arctica* relies to some extent on dispersal by migratory northern breeding birds that winter on the coast, ecological conditions in arctic nesting habitats could be important to this species.

C. Threats to the Species

Threats to *S. arctica* are actions that disrupt habitat conditions necessary for its survival, or collecting specimens for scientific purposes from limited populations. Because this species is found on coastal rocks and soil or on coastal mountain summits, recreational activities like hiking, mountain biking, off-road vehicle use, and trail or shelter building could threaten this species.

D. Distribution Relative to Land Allocations

The two known sites of *S. arctica* in the range of the Northwest Forest Plan are on State Park land, one in Oregon and one in Washington.

III. MANAGEMENT GOAL AND OBJECTIVES

A. Management Goal for the Species

The goal for the managing *S. arctica* is to assist in maintaining species viability.

B. Objectives

Manage known sites if they are found on federal land administered by the Forest Service or BLM by maintaining existing habitat conditions associated with *S. arctica*.

IV. HABITAT MANAGEMENT

A. Lessons From History

No information on the history of *S. arctica* and management activities is available.

B. Identifying Habitat Areas for Management

Any known sites found on lands administered by Forest Service or BLM will contribute to maintaining this species in the range of the Northwest Forest Plan, and are identified as habitat areas where these management recommendations should be implemented.

C. Managing in Habitat Areas

If *S. arctica* is found on federal land, avoid any direct physical impact to the local population, and maintain the existing habitat conditions at each site. Manage population to restrict impacts from recreational activities that may directly harm the population. Given the rarity of this species in the range of the Northwest Forest Plan, voucher specimens should not be collected. A lichenologist should visit the site to verify identification.

D. Other Management Issues and Considerations

When requested, share information and expertise with appropriate State officials to further activities directed at conservation of *S. arctica* on non-federal lands. Determine if this species meets the criteria for close association with late-successional or old-growth forests. Given the apparent rarity of this species, it should be considered for evaluation as a sensitive species in Oregon and Washington.

V. RESEARCH, INVENTORY, AND MONITORING NEEDS

The objective of this section is to identify opportunities to acquire additional information that could contribute to more effective species management. The content of this section has not been prioritized or reviewed as to how important the particular items are for species management. The inventory, research, and monitoring identified below are not required. These recommendations should be addressed by a regional coordinating staff.

A. Data Gaps and Information Needs

- Determine if *S. arctica* meets the criteria for close association with late-successional or old-growth forests.
- Determine if *S. arctica* occurs on federal lands along the Washington, Oregon, and northern California coast or in other sites in the range of the Northwest Forest Plan by conducting surveys in areas identified as potential suitable habitat.
- Determine mechanisms and rates of reproduction, dispersal, and growth.

B. Research Questions

- Are the sites of *S. arctica* in the range of the Northwest Forest Plan glacial relicts?
- How do the genotypes of the disjunct southernmost local populations of S. arctica compare to populations in the center or more northern parts of its range?
- What are the dispersal distances of *S. arctica*?
- Are the habitat characteristics for *S. arctica* in the range of the Northwest Forest Plan similar to those of its arctic counterparts?

C. Monitoring Needs and Recommendations

Population trends should be monitored at any known sites discovered on Forest Service or BLM land in the range of the Northwest Forest Plan.

Sticta arctica

Teloschistes flavicans

SUMMARY

Species: *Teloschistes flavicans* (Sw.) Norman
Taxonomic Group: Lichens (Rare Oceanic-Influenced)
ROD Components: 1, 3

Other Management Status: Oregon Natural Heritage Program List 2 (taxa that are threatened with extirpation from the State of Oregon). Natural Heritage Networks Rank Global Rank G4 (not rare and apparently secure, but with cause for long-term concern, usually with more than 100 occurrences). State Rank S1 (critically imperiled because of extreme rarity or because it is somehow especially vulnerable to extinction or extirpation in Oregon, typically with 5 or fewer occurrences) (Oregon Natural Heritage Program 1998). BLM Assessment Status (USDI Bureau of Land Management 1998).

Range: In the range of the Northwest Forest Plan, the only substantial population of *Teloschistes flavicans* is at Cape Lookout State Park, Oregon. Minor populations occur at New River ACEC (BLM), near Pacific City (BLM), Sand Lake, Cape Blanco State Park and Harris Beach State Park, all in Oregon. *T. flavicans* is a widespread tropical and subtropical genus in the Western Hemisphere.

Specific Habitat: *T. flavicans* is confined to forested headlands and dunes of the coastal fog belt, especially on capes or peninsulas. It occurs on exposed branches, twigs and boles of Sitka spruce, shore pine and stems of Hooker's willow in old Sitka spruce/western hemlock or shore pine stands.

Threats: The main threats are activities that directly harm the populations, their habitat, or the potential habitat surrounding populations. Examples of potential threats include burning (in some places); harvesting trees; constructing roads, trails or buildings; recreational activities; grazing; invasive exotic plants; hydrologic changes; and air pollution.

Management Recommendations:
- Manage known sites to maintain local populations and their habitat area.
- Develop practices to route human use away from known sites.
- Manage fire in habitat areas, with emphasis on prevention.
- Restrict removal of trees, shrubs, moss, or other vegetation from known sites and habitat area, except when removal will not harm habitat integrity.
- Consider opportunities for managing known sites during Forest Plan and Resource Management Plan revisions, such as administratively withdrawn designations, or by prescribing special standards and guidelines.

Information Needs:
- Visit known sites to determine the extent of local populations and improve habitat descriptions.
- Determine if *T. flavicans* is closely associated with late-successional or old-growth forests.
- Determine if additional populations exist in areas identified as potential suitable habitat.

I. NATURAL HISTORY

A. Taxonomy and Nomenclature

Basionym:

Lichen flavicans Swartz, Nov. Gen. Spec. Plant., 147 (1788)

Synonyms:

- *Teloschistes flavicans* Norman, Nyt. Mag. f. Naturvid, 7, 229 (1853)
- *Physcia flavicans* Hook., Hadb. N.Z. Fl., 572 (1867)
- *Teloschistes chrysophthalmus* var. flavicans (Swartz) Tuck.
- Teloschistes exilis (Michx.) Vainio

T. flavicans (Swartz) Norman is a lichenized fungus in the family Teloschistaceae, order Lecanorales, class Ascomycetes (Tehler 1996). The photobiont is a species of *Trebouxia*, a green alga (Murray 1960).

B. Species Description

1. Morphology and Chemistry

T. flavicans is a conspicuous, small to medium sized, fruticose lichen (**Figure 27**). The thallus is tufted, erect and spreading or, rarely, pendent, and yellow to orange colored. It is occasionally greenish-yellow, or even pale greenish, when grown in the shade (McCune and Geiser 1997). It is composed of many elongated, entangled, somewhat compressed, more or less twisted, pitted or channeled, sorediate branches (Fink 1935). The branches have pointed tips and short pointed side branches, also called cilia (Sanders 1993). The soredia are yellowish in roundish soralia. Apothecia are unknown. The cortex is K+ purple-red, the medulla is K-, KC-, C-, PD- (McCune and Geiser 1997).

A similar but smaller non-sorediate species with apothecia, *T. exilis* (Michx.) Vain., has been collected in the Santa Cruz Mountains and the Channel Islands but is now very rare (Hale and Cole 1988).

2. Reproductive Biology

Asexual reproduction occurs via soredia and thallus fragmentation. Sexual reproductive structures are unknown. The genus as a whole is considered, by some, to be extremely ancient and very slow evolutionary rates have left many species little changed over millions of years (Kärnefelt 1991). In Britain (Gilbert and Purvis 1996), *T. flavicans* can spread locally on an individual tree or boulder but disperses only very slowly to adjacent rocks or tree boles.

3. Ecological Roles

Little is known about the ecological roles of *T. flavicans* in the Pacific Northwest. In general, lichens are able to use not only rain but also fog, dew or atmospheric water vapor as a source of water for positive net photosynthesis. The genus *Teloschistes* is particularly well adapted to low annual rainfall, frequent overcast and fogs with associated high humidity. The ability to reactivate under low thallus moisture content (as low as 15% for *T. capensis*) enables them to grow in areas with low or no rain but with high amounts of atmospheric moisture, most of which is unavailable to vascular plants. Where terricolous (ground-dwelling) species of *Teloschistes* form the predominant component of the perennial plant biomass (Lange *et al*. 1990, Gilbert and Purvis 1996), they are very important in stabilizing soil and protecting it from wind erosion.

C. Range and Known Sites

Figure 28. Drawing of *Teloschistes flavicans.*

T. flavicans is a widespread tropical and subtropical species that occurs sporadically along the west coast of the Americas from Ecuador to northern Oregon (McCune and Geiser 1997). Although Fink (1935) reported *T. flavicans* along the eastern seaboard from Massachusetts to Florida, and from Texas, Oregon and Nevada, he considered *T. flavicans* and *T. exilis* to be conspecific. Hale's (1979) maps show the latter species only from southern California and southern Texas, Louisiana and Mississippi. However, a current search and re-examination of collections at Duke University and the US National Museum at the Smithsonian Institute conducted by Dr. Irwin Brodo of the Canadian National Museum (pers. comm. 1997), revealed that *T. flavicans* does indeed occur on the eastern seaboard in Georgia, North Carolina, Massachusetts, and Nova Scotia. Although *T. flavicans* occurs sporadically in coastal California in Sonoma, Marin, Monterey, San Diego, San Mateo, Santa Barbara, and San Luis Obispo Counties, none of these sites are within the range of the Northwest Forest Plan.

In the area covered by the Northwest Forest Plan, *T. flavicans* is currently known only from Oregon. The only substantial population of *T. flavicans* is at Cape Lookout State Park (Tillamook County) in northern coastal Oregon (McCune and Geiser 1997). Two sites with minor populations are known on federal land: New River Area of Critical Environmental Concern (ACEC) in Curry County on the BLM Coos Bay District, and a BLM Salem District parcel just north of Pacific City (Tillamook County). The remaining known populations are small and are not on federal land: Sand Lake vicinity 10 km (6 mi) south of Cape Lookout (Tillamook County); Cape Blanco State Park and Harris Beach State Park (Curry County).

D. Habitat Characteristics and Species Abundance

T. flavicans is rare throughout the range of the Northwest Forest Plan, and reaches the apparent northern limits of its range in Oregon. Within this area, it appears to be confined to exposed headlands and dunes of the immediate coast in Oregon. All known sites are under 200 m (660 ft) elevation. At Cape Lookout, where the largest known population is located, *T. flavicans* is found on the twigs of Sitka spruce (*Picea sitchensis*) and is common in the litterfall of an old Sitka spruce forest on the long, forested headland of the peninsula. At Cape Blanco, *T. flavicans* grows on the boles and limbs of exposed Sitka spruce and Hooker's willow (*Salix hookeriana*) in an open Sitka spruce forest. At New River ACEC, where it is rare, it is found on shore pine (*Pinus contorta*) in a mature shorepine forest at the edge of a pasture. At Sand Lake it occurs on Sitka spruce. Just 1 km (0.6 mi) northwest of Pacific City, it occurs in the twig litterfall of a small, old, mixed shore pine and Sitka spruce forest on a knoll east of the dune. In southern California, *T. flavicans* grows on conifers and other trees (e.g., *Quercus*) in coastal scrub stands. One collection from San Mateo County is on sandstone.

In Great Britain, *T. flavicans* displays a habitat range that encompasses epiphytic, saxicolous (rock-dwelling) and terricolous communities. All the terricolous and saxicolous sites are coastal; inland it occurs only as an epiphyte. Host plants include ash (*Fraxinus*), maple (*Acer*), oak (*Quercus*), cherry (*Prunus*), alder (*Alnus*), and rhododendron (*Rhododendron*). The typical host tree is large, free-standing and with a well-illuminated trunk exposed to the wind, typically at a height of 1-4 m (3-12 ft) on the trunk, but, if the canopy is open, it may extend high into the upper branches. The largest colonies are on coastal granite, and encompass many thousands of plants. Around 1% of the British population is terricolous, growing up to 15 cm (6 in) deep between wind-clipped heaths or on soil with *Armeria* (sea-pink), fescue (*Festuca*), plantain (*Plantago*) and stonecrop (*Sedum*). In windswept locations where the higher plant cover is very open, it can be attached to other lichens, the soil or to fescue culms (Gilbert and Purvis 1996).

II. CURRENT SPECIES SITUATION

A. Why Species is Listed Under Survey and Manage Standard and Guideline

T. flavicans was considered at risk under the Northwest Forest Plan because of its rarity and limited distribution within the range of the northern spotted owl (USDA and USDI 1994a, 1994b). At the time of the viability panel, *T. flavicans* was only known from two populations in the range of the northern spotted owl (USDA and USDI 1994a, 1994b). Ratings by the lichen viability panel reflected a high level of concern for this species. The rare oceanic-influenced lichens as a group received the lowest viability ratings among all the lichens considered (USDA and USDI 1994a).

Because of the low viability ratings and high level of concern, this species was identified as a Survey and Manage Strategy 1 and 3 species, with the dual objectives of managing known sites, and conducting extensive surveys to locate additional populations and identify other high-priority sites for species management (USDA and USDI 1994c).

B. Major Habitat and Viability Considerations

Frequent fog along the coast, combined with moderate temperatures, create suitable habitat for oceanic-influenced lichens such as *T. flavicans*. The broken topography, natural firebreaks and ocean spray all act to reduce the influence of fire on the immediate coast, thus favoring higher species diversity and successful colonization by rare species such as *T. flavicans* (McCune et al. 1997).

The major concerns for this lichen are the small number of populations, the limited amount of suitable habitat for this species on federal land, and loss of populations from management activities that directly impact the remaining habitat or populations. Much of the low elevation coastal forest land in the Pacific Northwest is under non-federal ownership. This land includes thousands of acres that are generally managed on short harvest rotations. Given that lichens are slow to establish in rapidly growing stands (USDA and USDI 1994a) and do not become abundant until later in successional development, most of these stands are harvested before lichens have a chance to re-establish significant populations.

Isolation of populations also leads to genetic isolation. Almost nothing is known about the genetics of lichen populations or the effects of gene pool isolation on local extinction rates of populations.

C. Threats to the Species

Threats to *T. flavicans* are those actions that disrupt stand conditions necessary for its survival. Such actions include treatments that reduce local populations by removing colonized bark or wood substrates; decreasing exposure to light; adversely affecting integrity of habitat areas; reducing or fragmenting potential habitat; or degrading air quality.

Recreational activities and developments may inadvertently alter the habitat of this species. Trampling by recreational vehicles and frequent foot traffic are serious threats, especially in shore pine woodlands and edge communities, as these degrade the habitat by disturbing fragile root systems of trees and shrubs, and the fragile protective mats of ground cryptogams, which stabilize the soil (Christy et al. 1998). Destabilization of the foredunes by recreationists or removal of European beachgrass (*Ammophila arenaria*) can destabilize tree island habitats of *T. flavicans* by increasing the amount of sand drift into them and burying trees on the perimeter (Christy et al. 1998). Buildings, roads, campgrounds and trails along the immediate coast have replaced many natural habitats to improve access, facilitate scenic views, or develop recreational uses.

Other threats to the integrity of habitat and potential habitat areas include logging, grazing, agriculture, and activities which alter local hydrology, or increase fire frequency (Christy et al. 1998). Concern about fire varies— many different plant communities and successional stages exist among the coastal dunes and headlands; fire is beneficial to some communities but damaging to others. Invasion or planting of exotics such as Scots broom (*Cytisus scoparium*), European beachgrass, tree lupine (*Lupinus arboreus*), birdsfoot-trefoil (*Lotus corniculatus*), and iceplant (*Mesembryanthemum* spp.) can have profound effects on nitrogen-poor dune soils by increasing nitrogen and soil moisture. These conditions foster invasion of other weeds, eventually disrupting native plant communities (Christy et al. 1998) and reducing plant and animal diversity (USDI 1997).

T. flavicans is considered highly sensitive to air pollution; it cannot tolerate sulfur dioxide concentrations of 20 ppm (Gilbert and Purvis 1996). Because the primary habitat of this lichen is the coastal fog belt, and because fog significantly concentrates pollutants, especially acidic forms of SO_x and NO_x to which lichens are most sensitive, the potential vulnerability of *T. flavicans* to air-quality deterioration is a reasonable concern. Air quality is relatively good at known sites, but emissions from increased traffic (mainly NO_x) or new point sources (SO_x and NO_x), could threaten this species in the future.

Climate change affecting coastal fog patterns could be expected to affect the vigor of this species, possibly resulting in an even more restricted distribution or contributing to local extirpation.

D. Distribution Relative to Land Allocations

The key population of *T. flavicans* in the area of the Northwest Forest Plan is at Cape Lookout State Park, Oregon. *T. flavicans* occurs at two sites on federal land, but both support only small populations. The New River Area ACEC on the Coos Bay District BLM is administratively withdrawn. The land allocation for the Salem District BLM parcel just north of Pacific City is unknown at this time

III. MANAGEMENT GOAL AND OBJECTIVES

A. Management Goal for the Species

The goal for managing *T. flavicans* is to assist in maintaining species viability.

B. Objectives

Manage populations at all known sites on federal lands by maintaining habitat and potential habitat immediately surrounding known populations.

IV. HABITAT MANAGEMENT

A. Lessons From History

The majority of species in the genus *Teloschistes* are known only from scattered localities in isolated regions (Kärnefelt 1991). Scattered populations may cushion a species against world-wide extinction, but individual populations can be very vulnerable. Giess (1989) documented a dramatic decline in one such isolated population of *T. capensis* in Namibia that resulted from mechanical damage by off-road vehicles. A population of *T. flavicans* in Britain was lost to rabbit grazing (Gilbert and Purvis 1996). In southern California, *T. flavicans* is now quite rare because of urbanization and loss of habitat (Hale and Cole 1988).

One of the best documented declines of *T. flavicans* was described recently by Gilbert and Purvis (1996). Using accurate historical records, they were able to document the loss of most inland populations of *T. flavicans* in central England and Wales since 1960. The authors believe the gradual contraction of *T. flavicans* is largely from the spread of air pollution in central and southern England. Although some large saxicolous and terricolous populations remain on the coast, the remaining epiphytic colonies are threatened, even within the clean air area of southwest England. This is because most populations are on single, large mature trees and appear unable to spread onto adjacent trees or bushes. Thus the lifespan of the population is limited by that of its host. Eight sites are known to have been lost from tree mortality or destruction over the last 25 years. General land use changes have also been detrimental, particularly the clearing of old orchards and wayside trees and the death of elms; all were once major habitats.

Lichens have been known to be sensitive to air pollution for over a century. Many species in Europe are in an active state of decline from sulfur dioxide, nitrogen oxides and acidic deposition of sulfur and nitrogen containing pollutants (Ferry et al. 1973, Hawksworth and Rose 1976). Fog contains higher levels of dissolved ions and acidity than precipitation, rain or snow (James and Wolseley 1992). Lichens that obtain most of their water from fog and dew, are particularly vulnerable to air quality and weather pattern changes (Nash 1996). Follmann (1995) documented massive impoverishment and retrogression of lichens over much of the northern Chilean coastal fog belt during the past twenty years. Increasing frequency of El Niño events and gradually increasing aridity were postulated as likely, but not exclusive, causal factors in this decline. *T. flavicans* is a highly sensitive member of the coastal fog belt community of the Americas.

B. Identifying Habitat Areas for Management

All known sites of *T. flavicans* on federal land administered by the Forest Service and BLM in the range of the Northwest Forest Plan are identified as habitat areas where these management recommendations should be implemented. A habitat area for management is defined as suitable habitat occupied by or near a known population.

C. Managing in Habitat Areas

The objective of management within habitat areas is to maintain habitat conditions for *T. flavicans*. Specific habitat conditions known for *T. flavicans* are the foggy coastal headlands and dunes with old Sitka spruce, western hemlock, shore pine, or Hooker's willow.

- Determine the extent of the local population and habitat area with a site visit.
- Maintain suitable habitat around the current host trees and shrubs, so that the lichen may have adequate new substrate as current substrates decline.
- Develop practices to route human use away from the populations in habitat areas (e.g., divert roads, trails and off-road vehicles). Trampling shrubs or ground vegetation, compacting roots,

damaging trees or branches that serve as substrates, introducing non-native species by seed dispersal or planting, can all adversely affect habitat integrity.
- Avoid harvesting trees, shrubs, or other vegetation from the population and the habitat area unless these actions would do no harm to, or would improve, the habitat for *T. flavicans* (e.g., by preventing deeply shaded conditions or by removing invasive exotics).
- Prevent fire in the population but utilize or prevent fire in the habitat areas, depending on the role of fire in the plant community. Consider recommendations by Christy et al. (1998) for fire management in coastal plant communities.
- Restrict commercial collection of moss or fungi or other special forest products if these activities would adversely affect the integrity of habitat areas.

D. Other Management Issues and Considerations

- No key populations exist on federal land. Discovery of large populations on federal land or successful transplantation of this lichen to suitable habitat on federal land would reduce persistence concerns.
- Consider opportunities for managing known sites during Forest Plan and Resource Management Plan revisions, such as Botanical Special Interest Areas, Areas of Critical Environmental Concern, or other administratively withdrawn designations, or by prescribing special standards and guidelines.
- Share information with State and private sectors to further activities directed at conserving *T. flavicans*.
- Continue to work with state and federal regulatory agencies to protect air quality on federally-managed lands from on- or off-site emissions, especially of nitrogen- and sulfur-containing pollutants.
- Provide information about conserving rare lichens at visitor centers or other locations along the coast to build public support of conservation efforts and to discourage collection of specimens.

V. RESEARCH, INVENTORY, AND MONITORING NEEDS

The objective of this section is to identify opportunities to acquire additional information that could contribute to more effective species management. The content of this section has not been prioritized or reviewed as to how important the particular items are for species management. The inventory, research, and monitoring identified below are not required. These recommendations should be addressed by a regional coordinating staff.

A. Data Gaps and Information Needs

- Visit known sites to determine the extent of local populations and improve habitat descriptions.
- Determine if *T. flavicans* meets the criteria for being closely associated with late-successional or old-growth forests.
- Determine whether additional populations exist in areas identified as potential suitable habitat. Potential suitable habitat is foggy coastal windswept headlands and dunes with scattered old Sitka spruce, shore pine, western hemlock, especially on capes and jutting peninsulas.
- Prioritize Strategy 3 surveys in areas where management treatments or projects are scheduled or proposed in potential suitable habitat.

B. Research Questions

- What are the dispersal rates and mechanisms of *T. flavicans*?
- Which habitat characteristics are necessary for establishment and survival of *T. flavicans* propagules and colonies?

- What are the minimum and optimum patch sizes of colonized habitat necessary to provide for *T. flavicans*?
- Can transplants be used to create new populations for *T. flavicans* to increase its population base on federal land?
- What is the genetic diversity of *T. flavicans* in local populations and across the region?

C. Monitoring Needs and Recommendations

- Monitor dispersal and population trends of existing populations.
- Monitor known sites for changes in micro-climatic conditions, successional changes, and for inadvertent habitat damage from human activities or wildfire.
- Monitor air-quality effects on *T. flavicans*. Evaluate point sources and regional or local urban emissions along the coast within the range of the Northwest Forest Plan. Monitor populations at highest risk.

Tholurna dissimilis

SUMMARY

Species: *Tholurna dissimilis* (Norman) Norman
Taxonomic Group: Lichens (Rare Leafy)
ROD Components: 1, 3

Other Management Status: Oregon Natural Heritage Program List 3 (more information is needed before status can be determined, but which may be threatened or endangered in Oregon or throughout their range). Natural Heritage Network Ranks Oregon State Rank S1 (critically imperiled because of extreme rarity or because it is somehow especially vulnerable to extinction or extirpation, typically with 5 or fewer occurrences). Global Rank G4 (not rare and apparently secure, but with cause for long-term concern, usually with more than 100 occurrences) (Oregon Natural Heritage Program 1998). BLM Bureau Assessment Status in Oregon (USDI 1998).

Range: *Tholurna dissimilis* was previously thought to be endemic to Scandinavia until it was discovered in North America. It ranges from the Northwest Territories, Yukon, and British Columbia, south into Washington and Oregon, where it reaches its southern limit in the central Oregon Cascades. It is known from 18 sites in Washington and three sites in Oregon; all but one known site is on federal land. In Washington, it occurs on the Mt. Baker-Snoqualmie, Wenatchee, Okanogan, and Gifford Pinchot NFs; Mt. Rainier and Olympic National Parks; and Carson National Fish Hatchery where it was recently extirpated. In Oregon, it is reported from the Mt. Hood and Willamette NFs.

Specific Habitat: In the Pacific Northwest, the typical habitat for *T. dissimilis* is on krummholz or flag-form subalpine fir and Engelmann spruce on windswept ridges in the upper montane and subalpine zones up to timberline. It was recently reported from the top of an old-growth Douglas-fir at the canopy crane site in southern Washington. The elevational range of known sites is from near sea level at Port Angeles, Washington to 2042 m (6700 ft). In Oregon, reported populations occur at treeline on subalpine fir, and in an alpine area on wild currant twigs.

Threats: The main threat to *T. dissimilis* is loss of populations resulting from activities that affect the populations or their habitat, particularly removing colonized substrate. Current known populations in Washington are considered at low risk from management activities because most sites are not managed for timber production. This species is at higher risk in Oregon because it is known from only three sites. A warming climate may stress populations at the southern limit of this species' range, and could result in a decline in vigor and a more restricted distribution.

Management Recommendations: Manage populations at known sites by maintaining the ecological conditions associated with *T. dissimilis*, including occupied substrate and associated microclimate and stand conditions.

Information Needs:
- Determine the distribution of populations, species abundance and ecological requirements of *T. dissimilis* across the area covered by the Northwest Forest Plan.
- Determine if *T. dissimilis* is sensitive to air pollution.

I. NATURAL HISTORY

A. Taxonomy and Nomenclature

T. dissimilis (Norman) Norman is monotypic. The species is in the family Caliciaceae, order Caliciales (Tehler 1996). No specific information is currently available regarding its taxonomic history.

B. Species Description

1. Morphology

T. dissimilis is a very distinctive, dwarf, fruticose lichen composed of short, erect, hollow gray stalks (**Figure 28**). The tiny stalks are 1-3 (5) mm tall and 1 mm broad, arising from a squamulose to nearly crustose primary thallus. The brownish-gray stalks form a coarse stubble, and terminate with black apothecia, which dissolve into a powdery mass of spores. *T. dissimilis* is obscure because of its diminutive size.

Technical description: Squamulose thallus of once-pinnate sterile lobes bearing erect, nearly cylindrical sulcate fertile podetia 1-3 mm high. Thallus dark brown to black and with upper and lower cortex and a spongy medulla. Green algal photobiont is *Protococcus*. Cup-shaped black apothecia are solitary on the apices of the gray podetia, which are expanded to a disciform receptacle. Asci slender and narrowed at the base to a thin stalk, 8-spored, the spores uniseriate. Spores composed of two globose cells and constricted in the middle; each cell with spiral diagonal-striped apispore. Conceptacle of the pycnoconidia at the edge of the thallus, small, wart-like and brownish, and with a soft wall. Sporophores septate and with nearly globose cells; pycnoconidia straight, constricted in the middle, possessing secondary branches (Otto 1964).

2. Reproductive Biology

T. dissimilis reproduces sexually by producing ascospores. It is not known to produce isidia or soredia.

3. Ecological Roles

Little is known about the ecological roles of *T. dissimilis*.

C. Range and Known Sites

T. dissimilis, once thought to be endemic to Scandinavia (Otto 1964), is known from the Northwest Territories, Yukon, and British Columbia south into Washington and Oregon (Otto 1983). It reaches its southern limit in the central Oregon Cascades, and is known from 18 sites in

Washington and three sites in Oregon. All known sites are on federal land with the exception of a Port Angeles location. In Washington it is found in Clallam, Whatcom, Snohomish, King, Chelan, Pierce, Lewis, and Skamania Counties. Known sites on federal lands in Washington include Hurricane Ridge (Olympic National Park); the Mt. Baker-Snoqualmie NF on Skyline Divide, Table Mountain, Tomyhoi Peak area, White Mountain in the Glacier Peak Wilderness, Mt. Defiance in Alpine Lakes Wilderness, and Crystal Mountain Ski Area; Lake Wenatchee Ranger District on the Wenatchee NF, and above Harts Pass near the Cascade Crest on the Okanogan NF. It has been reported on the Gifford Pinchot NF from Castle Butte on the Cowlitz Valley Ranger District, and the canopy crane site on the Wind River District. There was a known site at the Carson Fish Hatchery in southern Washington, although that population no longer exists (J. Davis, pers. comm.). The only known site on non-federal land is at low elevation near Port Angeles, Washington.

In Oregon, there are three known sites. It has been reported from the Mt. Hood Wilderness. The two sites on the Willamette NF at Iron Mountain and Carpenter Mountain represent the known southern limit of this species. The rarity of *T. dissimilis* in Oregon, its sparseness, and stunted condition suggest that conditions at the southernmost site are near the limit for its growth (Pike 1972).

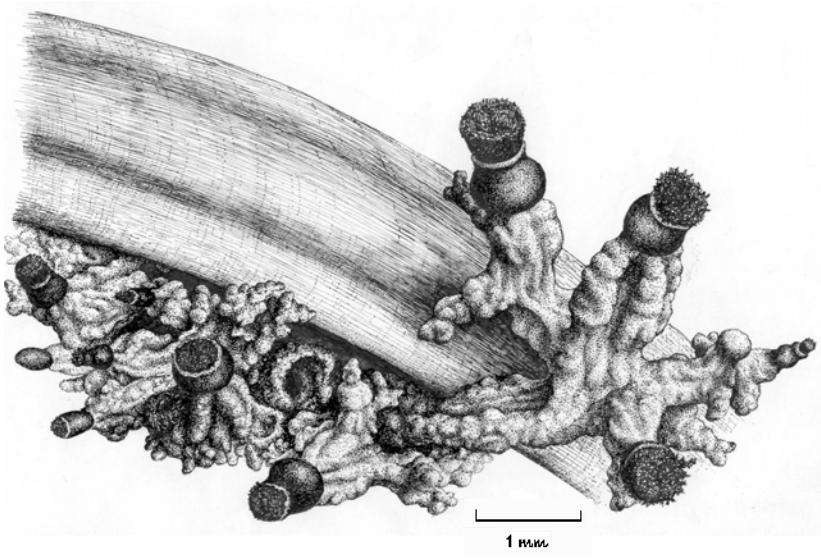

Figure 29. Drawing of *Tholurna dissimilis.*

D. Habitat Characteristics and Species Abundance

In the Pacific Northwest, the typical habitat reported for *T. dissimilis* is on krummholz or flag-form subalpine fir (*Abies lasiocarpa*) and Engelmann spruce (*Picea engelmannii*) on windswept ridges in the upper montane and subalpine zones up to timberline. The elevation of known sites in this region ranges from near sea level to 2042 m (6700 ft). Atypical habitat characteristics include the historic location on ornamental birch (*Betula*) near the Carson Fish Hatchery, on alder (*Alnus*) near Port Angeles, and on rock on a mountain summit in Lewis County. In Oregon, populations were reported at treeline on subalpine fir, and in an alpine area on wild currant (*Ribes triste*).

T. dissimilis appears to be rare in Oregon, becoming more common to the north in British Columbia. Abundance data for this species are not currently available.

There has been only one report of *T. dissimilis* from low- elevation tree canopies in the range of the northern spotted owl, but few if any surveys have been conducted in this habitat. In the Kitimat Valley of west-central British Columbia, it was found in the emergent crowns (40 m height, 131 ft) of dominant spruce (presumably *Picea sitchensis*) in low elevation forests (150 m, 492 ft) (Otto 1983). *T. dissimilis* was recently observed at the very top of an emergent spike-top old-growth Douglas-fir (*Pseudotsuga menziesii*) at the canopy crane site at Wind River on the Gifford Pinchot NF (J. Davis, pers. comm.). This recent discovery is evidence that *T. dissimilis* occurs in tree canopies other than krummholz, and at lower elevations.

II. CURRENT SPECIES SITUATION

A. Why Species Is Listed Under Survey and Manage Standard and Guideline

T. dissimilis was considered at risk under the Northwest Forest Plan because of its presumed rarity in the range of the northern spotted owl (USDA and USDI 1994a); at the time of the lichen viability panel, it was known from nine sites in this region (USDA and USDI 1994b). In addition, concern for species viability was noted for lichens in general because of their sensitivity to air pollution (USDA and USDI 1994a, 1994b), but the pollution sensitivity of *T. dissimilis* is unknown. Persistence concerns for *T. dissimilis* are moderate in northern Washington as there are relatively few known populations. The persistence concerns become much higher in Oregon where only three isolated populations are known to exist. Because of persistence concerns, *T. dissimilis* was listed as a Survey and Manage Strategy 1 and 3

species (USDA and USDI 1994c), with the objectives to manage known sites and to conduct extensive surveys to identify high priority sites for management.

B. Major Habitat and Viability Considerations

The major viability consideration for *T. dissimilis* is loss of populations resulting from management activities that affect the populations or their habitat, particularly removing colonized substrate. Current known populations in northern Washington are considered at low risk from management activities because many known sites are krummholz trees at timberline, and most sites are in Wilderness areas, or in areas not managed for timber production. The occurrence of *T. dissimilis* in exposed ridgetop habitats may make it more vulnerable to air pollution, if it is determined that *T. dissimilis* is sensitive to pollutants. A warming climate may contribute to a decline in vigor of this species at the southern limit of its range, and could result in an even more restricted distribution for *T. dissimilis*.

C. Threats to the Species

Threats to *T. dissimilis* are those actions that affect populations, particularly removing colonized substrate. A significant deterioration in air quality could threaten the viability of this species, considering the exposed nature of the habitat it occupies—that is ridgetops, mountain summits, and tree canopies.

D. Distribution Relative to Land Allocations

The distribution of *T. dissimilis* relative to land allocations needs to be determined. Each administrative unit should evaluate the land allocations for known sites on lands within its jurisdiction, and share this information at the regional level.

III. MANAGEMENT GOAL AND OBJECTIVES

A. Management Goal for the Species

The goal for managing *T. dissimilis* is to assist in maintaining species viability.

B. Objectives

Manage known sites on federal lands by maintaining habitat, stand structure, occupied and potential suitable substrate, and micro-climatic conditions associated with *T. dissimilis*.

IV. HABITAT MANAGEMENT

A. Lessons From History

T. dissimilis was recently discovered in North America (Otto 1964). Previously it was known only from Scandinavia. Since the discovery of *T. dissimilis* in western North America in the 1960s, many more sites have been documented. The number of known sites increased from eight in 1972 to 47 by 1981 (Otto 1983); 42 of these known sites are from western Canada in British Columbia, the Yukon and Northwest Territories (Otto 1983). Pike (1972) was the first to report *T. dissimilis* from Oregon; he also looked for this species in suitable habitat on Mt. Hood and Mt. Jefferson in Oregon, but did not find it. It was recently reported from the Mt. Hood Wilderness. It is possible that with additional surveys, this species may not be as rare as currently thought. In addition, the recent discovery of *T. dissimilis* in the upper crown of old-growth Douglas-fir at the canopy crane site expands our concept of suitable habitat for this

species in the area of the Northwest Forest Plan.

Many lichen species are known to be sensitive to air pollution, and lichen population declines attributed to air pollution have been documented in Europe and North America (Rao and LeBlanc 1967, Skye and Hallberg 1969, Hawksworth 1971, Ferry et al. 1973, Hawksworth and Rose 1976, Case 1980, Sigal and Nash 1983, Gilbert 1992). The sensitivity of *T. dissimilis* to air pollution is unknown.

The decline of lichens in Europe has resulted in the development of lists of threatened species. Sweden has a "red list" of lichens that are threatened with extinction because of air pollution and habitat degradation (Thor 1990). *T. dissimilis* is listed as rare on this list (Databanken for hotade arter och Naturvardsverket 1991). The International Association of Lichenology has recently initiated a listing of lichens threatened globally.

B. Identifying Habitat Areas for Management

Known sites of *T. dissimilis* on lands administered by the Forest Service and BLM in the range of the northern spotted owl are identified as habitat areas where these management recommendations apply. A habitat area is defined as suitable habitat occupied by or adjacent to a known population.

C. Managing in Habitat Areas

The goal of managing in habitat areas is to maintain the habitat conditions of *T. dissimilis*. Sites with known populations should be managed to include an area large enough to maintain the habitat, occupied substrate, and potentially suitable substrate associated with this species. Restrict collecting of specimens where the species is rare or of limited abundance.

At known sites where *T. dissimilis* occurs in flag-form or krummholz trees:

- Maintain occupied substrate, provide additional suitable substrate for colonization as current occupied substrates decline, and avoid damage to colonized substrate.
- The size of the habitat area for management should be determined by a field visit.

Known sites with populations that occur in the tops of old-growth trees will be problematic. It will be difficult to know if the species is present, as well as determining the extent of the population. At these sites:

- Maintain the tallest trees with exposed upper crowns in the stand, as well as trees with dead spike-tops if present.
- Accomplish this by selecting trees with these attributes for green tree retention.

D. Other Management Issues and Considerations

Current information suggests that *T. dissimilis* is sporadic in its distribution, and appears to be rare, particularly in the southern Washington and Oregon Cascades. This distribution may be a function of limited surveys or inventories in suitable habitat.

Until recently, information from known sites suggested that *T. dissimilis* may not be closely associated with late-successional or old-growth forests. However, the recent sighting of *T. dissimilis* in the exposed dead top of an emergent old-growth Douglas-fir confirms its occurrence in old-growth forests, as had been previously reported from British Columbia. This recent discovery illustrates how little we know of the distribution and ecology of *T. dissimilis* in the area of the Northwest Forest Plan.

- In the range of *T. dissimilis* where old forests are limited in extent, target the older stands in watersheds to meet the Standard and Guideline for 15% retention of old-growth in watersheds where little remains. Maintaining the older age classes across the landscape is important for *T. dissimilis* as this lichen does not occur in younger late-successional forests.

- Providing a well-distributed network of older forests in the range of *T. dissimilis* will provide stands to replace those lost to fire, blowdown, or other natural disturbance events.

V. RESEARCH, INVENTORY AND MONITORING NEEDS

The objective of this section is to identify opportunities to acquire additional information that could contribute to more effective species management. The content of this section has not been prioritized or reviewed as to how important the particular items are for species management. The inventory, research, and monitoring identified below are not required. These recommendations should be addressed by a regional coordinating staff.

A. Data Gaps and Information Needs

- Determine if additional populations of *T. dissimilis* exist in areas identified as potential suitable habitat. Assign priority for Strategy 3 surveys to timberline habitats especially near the southern edge of its range in Oregon and southern Washington, and to exposed upper crowns of conifers at lower elevation, particularly in areas of cold-air drainage.
- Determine the extent of the population of *T. dissimilis* at the canopy crane site. This is a unique opportunity to survey traditionally inaccessible habitat and to develop additional information on the distribution and abundance of *T. dissimilis* in this type of stand, as well as characterizing its habitat in tree crowns. This information could be used to improve our management of this species elsewhere.
- Revisit known sites to verify the status of known populations, determine the extent of the populations and abundance, and characterize ecological conditions.
- Determine if *T. dissimilis* meets the criteria for close association with late-successional or old-growth forests (Table VI-6, USDA and USDI 1994a).

B. Research Questions

- What habitat characteristics and ecological conditions are necessary for establishment of *T. dissimilis* propagules and survival of established thalli?
- What are the dispersal mechanisms and dispersal distances of this species?
- Is *T. dissimilis* sensitive to air pollution?
- What is the genetic diversity of this species within its local populations and across the region?

C. Monitoring Needs and Recommendations

- If management treatments occur in the vicinity of known sites, monitor population to determine response to treatment and effects on population viability.
- Monitor selected known sites to document population trends, particularly those populations at the edge of a species range, or those sites of atypical habitats.
- Consider establishing air quality monitoring sites near selected known populations of *T. dissimilis.*

Usnea hesperina

SUMMARY

Species: *Usnea hesperina* Mot.
Taxonomic Group: Lichens (Rare Oceanic-Influenced)
ROD Components: 1, 3

Other Management Status: Oregon Natural Heritage Program List 3 (more information is needed before status can be determined, but may be threatened or endangered in Oregon or throughout range). Natural Heritage Networks Rank Global Rank G5 (demonstrably widespread, abundant, and secure). State Rank S2 (imperiled because of rarity or because other factors demonstrably make it very vulnerable to extirpation, typically with 6-20 occurrences) (Oregon Natural Heritage Program 1998). BLM Tracking Status (USDI Bureau of Land Management 1998).

Range: *Usnea hesperina* has a world-wide distribution, and is known from ten sites in the range of the northern spotted owl, with nine sites in Oregon. Seven of the sites are on federal land. It is known from Eugene District BLM ACEC near Heceta Beach; McGribble Campground, Siskiyou NF; and the west shore of Ozette Lake in Olympic National Park. Four sites are on lands administered by the Siuslaw NF— Eel Creek and the south shore of Clear Lake in the Oregon Dunes National Recreation Area; Cascade Head Experimental Forest; and Sutton Creek Recreation Area. Non-federal sites are Lighthouse State Park, Humbug Mountain southeast of Port Orford, and near Clear Lake Dunes County Park vicinity.

Specific Habitat: *U. hesperina* is an epiphyte on coniferous trees and hardwood shrubs in forested and shrubby habitats of the coastal fog belt. All known sites are within 5 km (3 mi) of the Pacific Ocean. Some old trees or shrubs are present at all sites. The sites are exposed, such as a forest headland or ridge, or have exposed microhabitats.

Threats: Threats to *U. hesperina* are those actions that disrupt stand conditions necessary for its survival, including treatments that impact populations by removing coastal conifers and hardwood shrubs; alter the light, moisture, or temperature regimes; or deteriorate air quality. Such threats include fire (natural or prescribed), recreational development and activities, timber harvest, and off-road vehicles.

Management Recommendations:
- Manage known populations and the habitat area around them at all known sites.
- Develop practices to route human use away from habitat areas.
- Prevent fire in the population; manage fire in habitat areas.
- Restrict removal of trees, shrubs, or other vegetation from the habitat area, except when removal will not harm habitat integrity.

Information Needs:
- Visit known sites to determine extent of local populations, improve habitat descriptions, and clarify the association of this species with late-successional or growth forests.
- Determine whether additional populations exist in areas identified as suitable habitat.

I. NATURAL HISTORY

A. Taxonomy and Nomenclature

Usnea hesperina Mot., Lich. Gen. *Usnea* Stud. Monogr., Pars Syst. 2: 383. 1938.

Synonyms:

- *Usnea hesperina* ssp. *liturata* Motyka, Lich. Gen. *Usnea* Stud. Monogr., Pars Syst. 2:384. 1938.
- *Usnea elongata* Motyka, Lich. Gen. *Usnea* Stud. Monogr., Pars Syst. 2:411. 1938.
- *Usnea schadenbergiana* Göpp. & Stein, 60. Jahresber. Schles. Ges. Vaterl. Cult.: 229. 1883.
- *Usnea subplicata* (Vain.) Motyka, Lich. Gen. *Usnea* Stud. Monogr., Pars Syst. 2:558. 1938.
- *Usnea gracilis* var. *subplicata* Vain., Ann. Acad. Sci. Fenn., Ser. A 6:7. 1915.
- *Usnea subgracilis* Vain., Ann. Acad. Sci. Fenn., Ser. A 6:7. 1915.

U. hesperina Mot. was described by Motyka in 1938. It is a lichenized fungus in the family Parmeliaceae, order Lecanorales, class Ascomycetes (Tehler 1996). Motyka's species concept in the genus *Usnea* was largely influenced by geographic criteria, and some species common to different continents were described as different taxa. Motyka's material was recently re-examined by Clerc (1997), who concluded that *U. elongata*, *U. schadenbergiana*, *U. subplicata*, *U. gracilis* var. *subplicata*, and *U. subgracilis* are all synonyms of *U. hesperina*. In her recent treatise on *Usnea* in western Oregon, Pittam (1995) recognized two subspecies, *U. hesperina* ssp. *hesperina* and *U. hesperina* ssp. *liturata*, finding only the latter subspecies in her study area. Clerc (1997), Halonen et al. (1998), and McCune et al. (1997) all consider ssp. *liturata* a synonym of *U. hesperina*.

B. Species Description

1. Morphology and Chemistry

U. hesperina is characterized by its long, yellowish-green, pendent thallus, pale base, and strong annular cracks that become especially distinct towards the base (**Figure 29**). The branches are slender, epapillate and cylindrical (at most, slightly foveolate). The most variable characters are the frequency and distribution of the fibrils and soralia. The long, curved fibrils can be sparse to relatively abundant (Halonen et al. 1998). *U. hesperina* has superficial punctiform to tuberculate soralia, often becoming confluent near the apices. Immature soralia resemble pseudocyphellae. Isidiomorphs are sparse to scattered, forming on young soralia and regenerative parts of the cortex, often soon abraded (Herrera-Campos et al. 1998). The cortex is matte, soft and moderately thick (8-20%), the medulla is thin and compact (6-24%), and the central axis is thick (43-64%) (Clerc 1997, Halonen et al. 1998, Herrera-Campos et al. 1998). Apothecia are rare, known only from Mexican material; they are subterminal on small branches and fibrils (Herrera-Campos et al. 1998). *U. hesperina* contains usnic and protocetraric acids, with confumarprotocetraric acid (Cph-2) and traces of unknown substances. It is K+ yellow and PD+ orange (Halonen et al. 1998). A strain with usnic acid and compounds of the stictic acid group ("*U. schadenbergiana*") is found in the Philippines (Clerc 1997)

Halonen *et al*. 1998, Herrera-Campos et al. 1998). Apothecia are rare, known only from Mexican material; they are subterminal on small branches and fibrils (Herrera-Campos *et al*. 1998). *U. hesperina* contains usnic and protocetraric acids, with confumarprotocetraric acid (Cph-2) and traces of unknown substances. It is K+ yellow and PD+ orange (Halonen et al. 1998). A strain with usnic acid and compounds of the stictic acid group ("*U. schadenbergiana*") is found in the Philippines (Clerc 1997).

U. hesperina can resemble other pendent species of this genus in the Pacific Northwest. *U. trichodea* is also epapillate but is readily separated by its brown central axis; *U. chaetophora* is usually papillate, and has a blackened base, different cortex: medulla: axis ratios and different chemistry (Halonen et al. 1998). *U. subscabrosa* has a reddish base, and a thick, hard, shiny cortex. It produces soralia that are more variable in the same thallus and usually better developed than those of *U. hesperina*. Soralia of *U.*

subscabrosa are small to medium-sized (about half the branch diameter), and are mainly convex and tuberculate, infrequently superficial and confluent (Herrera-Campos et al. 1998).

If thin layer chromatography is available, *U. hesperina* may be easily differentiated from other species by the presence of protocetraric acid as the main lichen substance. Most of the other species in the Pacific Northwest have only minor amounts of protocetraric acid, if any. Protocetraric acid can be the main substance in *U. cornuta sensu latu* (often), *U. glabrata* (often), and *U. rigida sensu latu*. These species differ distinctly in morphology from *U. hesperina*. *U. cornuta sensu latu* and *U. glabrata*, having shrubby thalli with distinct soralia, constricted branches and lax medullas. *Usnea rigida sensu latu* has a fertile thallus without isidia and soredia (Halonen et al. 1998).

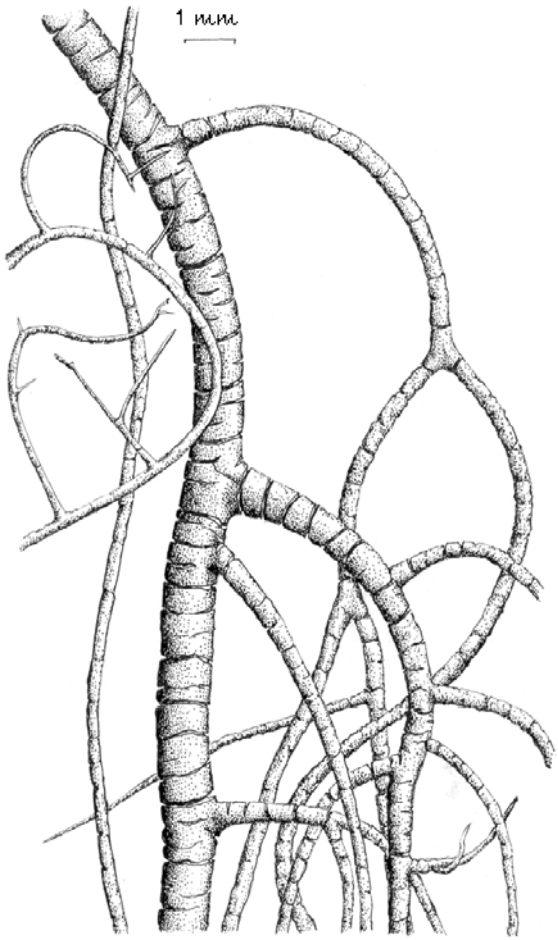

Figure 30. Drawing of *Usnea hesperina.*

2. Reproductive Biology

Sexual reproductive structures are unknown for *U. hesperina* in British Columbia (Halonen et al. 1998), or Oregon, and Washington (McCune et al. 1997), and are rare in Mexican material (Herrera-Campos et al. 1998).

Vegetative reproduction occurs by the production, dispersal and establishment of soredia, isidiomorphs and thallus fragments. The micro-scopic size of the reproductive propagules should allow them to be carried long distances by wind, animals, or birds. Birds in particular are thought to enhance arrival rates of rare oceanic species by dispersing lichen propagules along coastal migratory routes of the Pacific Northwest (McCune et al. 1997). In contrast, thallus fragments are heavier, fewer and therefore are likely to be most important for dispersal over short distances.

3. Ecological Roles

U. hesperina is a rare forage lichen. Squirrels, chipmunks, voles, pikas, mice, and bats and about 45 species of North American birds eat forage lichens or use them in nest building. A large variety of invertebrates including bristletails, barklice, katydids, grasshoppers, webspinners, butterflies, moths, lacewing larvae, mites, spiders, snails, slugs, and many beetles live on, mimic, or eat lichens (McCune and Geiser 1997). Fallen lichens are winter survival food for large animals such as deer and elk when snow depth prevents browsing. After windy periods and after snow melt, large quantities of forage lichens in the genera *Alectoria*, *Bryoria* and *Usnea* may be found on the ground (Esseen et al. 1981, Stevenson and Rochelle 1984). During conditions of deep snow, they provide critical winter nutrition to deer (Stevenson and Rochelle 1984).

C. Range and Known Sites

In North America, *U. hesperina* is found on the Pacific Coast (McCune et al. 1997, Halonen et al. 1998), the Atlantic seaboard, notably the southern Appalachians (Dey 1978), and in Jamaica, Cuba (Clerc 1992, 1997), and Mexico (Herrera-Campos et al. 1998). It is also known from Europe, Asia, Africa, South America, the Canary Islands, and the Philippine Islands (Clerc 1997).

In the range of the Northwest Forest Plan, *U. hesperina* is known from 10 sites, 9 in Oregon and 1 in Washington. Eight of the sites are on federal land: Eugene District BLM Area of Critical Environmental Concern (ACEC) near Heceta Beach (Lane County), McGribble Campground in the Gold Beach Ranger District of the Siskiyou NF (Curry County), the west shore of Ozette Lake, in Olympic National Park (Clallam County) and four sites on lands administered by the Siuslaw NF. The Siuslaw NF sites are Eel Creek (Coos County) and the shore of Clear Lake (Douglas County) in the Oregon Dunes National Recreation Area; Cascade Head Experimental Forest (Tillamook County) on the Hebo Ranger District; and Sutton Creek Recreation Area (Lane County) on the Mapleton Ranger District. The remaining known sites are Lighthouse State Park (Douglas County), and the road to Clear Lake Dunes County Park (Lane County).

D. Habitat Characteristics and Species Abundance

In the range of the Northwest Forest Plan the distribution of *U. hesperina* is limited to the coastal fog belt; all known sites are within 5 km (3 mi) of the Pacific Ocean. It is found as an epiphyte on coniferous trees and hardwood shrubs in various forested habitats that share the following characteristics: some old trees are present on the site, the trees are in an exposed location (headland, ridge, windswept dune), or the host trees are exposed in the stand (meadow edges, patchworks of shrubs and deciduous trees that shed leaves during the peak growing season of lichens, scrub forests on stabilized dunes and wetlands). No large populations of this lichen have been found, but individual thalli have been observed in an increasing number of places.

The known substrates of *U. hesperina* are Sitka spruce (*Picea sitchensis*), western hemlock (*Tsuga heterophylla*), Douglas-fir (*Pseudotsuga menziesii*), Hooker's willow (*Salix hookeriana*), evergreen huckleberry (*Vaccinium ovatum*), Pacific wax-myrtle (*Myrica californica*), and Pacific rhododendron (*Rhododendron macrophyllum*). At Ozette Lake, Washington, it was found in the litterfall of a Sitka spruce/western redcedar (*Thuja plicata*) forest. In southern Oregon, Curry County, it was found in the litterfall of a large Douglas-fir in a Douglas-fir, Oregon ash (*Fraxinus latifolia*), and tanoak (*Lithocarpus densiflorus*) forest. At several sites (Clear Lake, Heceta Beach, and Lighthouse State Park), it was found in openings or edges of Sitka spruce and shore pine (*Pinus contorta*) forests on stabilized sand dunes. At Cascade Head, it was found on boles and branches of western hemlock in a young riparian stand with a few remnant old Sitka spruce. It has not been found inland, despite systematic surveys on the Siuslaw NF and other forests of the western Cascades (USDA 1998). In British Columbia, *U. hesperina* is collected from conifers (*Picea* and *Tsuga*) along the hypermaritime seashore on Vancouver Island (Halonen et al. 1998). In the southern Appalachians, *U. hesperina* has a much more inland distribution and is common and widespread at lower elevations, where it occurs on hardwood trees, especially oak (*Quercus*) and birch (*Betula*), and rarely on rock and true fir (*Abies*) in communities dominated by hardwoods (Dey 1978).

II. CURRENT SPECIES SITUATION

A. Why Species Is Listed Under Survey and Manage Standard and Guideline

U. hesperina was thought to be at risk under the Northwest Forest Plan because of its rarity and limited distribution in the range of the northern spotted owl (USDA and USDI 1994a, 1994b). Ratings by the

FEMAT lichen viability panel reflected a high level of concern for this species (USDA and USDI 1994a). The rare oceanic-influenced lichens as a group received the lowest viability ratings among all the lichens evaluated (USDA and USDI 1994a).

Because of the low viability ratings and high level of concern, this species was identified as a Survey and Manage Strategy 1 and 3 species (USDA and USDI 1994c), with the dual objectives of managing known sites and conducting extensive surveys to locate additional populations and identify other high-priority sites for species management.

At the time of the viability panel, *U. hesperina* was known from only one site in the range of the northern spotted owl (USDA and USDI 1994a, 1994b). Work in this genus has been impeded until recently (Pittam 1995, Clerc 1997, Halonen et al. 1998, Herrera-Campos *et al*. 1998) by the lack of clear species descriptions and species concepts in the genus *Usnea*. Nine more locations have been found in the last few years, indicating that this species may be more frequent than was previously thought. None of the populations have been large, however.

B. Major Habitat and Viability Considerations

Frequent fog along the coast, combined with moderate temperatures, create the environment occupied by ocean-influenced lichens such as *U. hesperina*. The broken topography, natural firebreaks and ocean spray all act to reduce the influence of fire on the immediate coast. Migrating birds may enhance arrival rates by spreading lichen propagules. Higher species diversity, successful colonization by rare oceanic species, and reduced rates of population extirpations are natural features of immediate coastal habitats (McCune et al. 1997).

The major viability and habitat concerns for *U. hesperina* are the small number of known sites, the limited amount of suitable habitat for this species on federal land, and loss of populations because of management activities that directly affect the remaining populations, habitat areas or potential habitat. Much of the low-elevation coastal forest land in the Pacific Northwest is under non-federal management and, along the immediate coast, development pressures are increasing. Outside of urban areas, privately owned forests are generally managed on short harvest rotations. Given that lichens are slow to establish in rapidly growing stands (USDA and USDI 1994a), and do not become abundant until late in successional development, most of these stands are harvested before lichens have a chance to re-establish significant populations.

Isolation of populations also leads to genetic isolation. Almost nothing is known about the genetics of lichen populations or the effects of gene pool isolation on local extinction rates of populations.

C. Threats to the Species

Threats to *U. hesperina* are those actions that disrupt stand conditions necessary for its survival. Such actions include treatments that reduce local populations by removing colonized bark or wood substrates; decreasing exposure to light; adversely affecting integrity of habitat areas; reducing or fragmenting potential habitat; or degrading air quality.

Recreational activities and developments may inadvertently alter the habitat of this species. Trampling by recreational vehicles and frequent foot traffic are serious threats, especially in shore pine woodlands and edge communities, as these degrade the habitat by disturbing fragile root systems of trees and shrubs, and the fragile protective mats of ground cryptogams, which stabilize the soil (Christy et al. 1998). Destabilization of the foredunes by recreationists or removal of European beachgrass (*Ammophila arenaria*) can destabilize tree island habitats of *U. hesperina* by increasing the amount of sand drift into them and burying trees on the perimeter (Christy et al. 1998). Buildings, roads, campgrounds and trails

along the immediate coast have replaced many natural habitats to improve access, facilitate scenic views, or develop recreational uses.

Other threats to the integrity of habitat and potential habitat areas include logging, grazing, agriculture, and activities which alter local hydrology, or increase fire frequency (Christy et al. 1998). Concern about fire varies—many different plant communities and successional stages exist among the coastal dunes and headlands; fire is beneficial to some communities but damaging to others. McCune et al. (1997) propose that natural firebreaks along the coast have promoted a rich diversity of rare lichens. In Sweden, *U. longissima* was not found in young forests (<110 years) but survived in old spruce forests along mire edges, wet depressions and north-facing hill slopes that had escaped forest fires (Esseen et al. 1981, Zackrisson 1981 cited by Esseen *et al*. 1981).

Invasion or planting of exotics such as Scots broom (*Cytisus scoparium*), European beachgrass, tree lupine (*Lupinus arboreus*), birdsfoot-trefoil (*Lotus corniculatus*), and iceplant (*Mesembryanthemum* spp.) can have profound effects on nitrogen-poor dune soils by increasing nitrogen and soil moisture. These conditions foster invasion of other weeds and eventually disrupt native plant communities (Christy et al. 1998).

U. hesperina is assumed to be sensitive to air pollution, especially sulfur dioxide. Most other pendent species of *Usnea* in the Pacific Northwest (McCune and Geiser 1997) and elsewhere (Wetmore 1983, Insarova et al. 1992) with known sensitivities have been rated as sensitive or extremely sensitive. Because the primary habitat of this lichen is the coastal fog belt, and because fog significantly concentrates pollutants, especially acidic forms of SO_x and NO_x to which lichens are most sensitive, *U. hesperina* may be especially vulnerable to air pollution. Although air quality is relatively good at known sites, rising pollution emissions from increased traffic (mainly NO_x) and new or expanded industry (SO_x and NO_x) along the coast could threaten this species in the future. Climate change affecting coastal fog patterns could affect the vigor of this species, possibly resulting in an even more restricted distribution or contributing to local extirpation.

D. Distribution Relative to Land Allocations

U. hesperina is known from six federally managed administrative areas. The Eugene District BLM ACEC at Heceta Beach, Oregon, is administratively withdrawn. The Eel Creek and Clear Lake populations are in the Oregon Dunes National Recreation Area, which is Congressionally withdrawn, as is the Cascade Head Experimental Forest. McGribble Campground is in Matrix land on the Gold Beach District of the Siskiyou NF. The Sutton Creek site is part of Sutton Creek Recreation Area and is administratively withdrawn. The Ozette Lake population is in Olympic National Park.

III. MANAGEMENT GOAL AND OBJECTIVES

A. Management Goal for the Species

The goal for managing *U. hesperina* is to assist in maintaining species viability.

B. Objectives

Manage populations at all known sites on federal lands by maintaining habitat and potential habitat immediately surrounding known populations.

IV. HABITAT MANAGEMENT

A. Lessons From History

Habitat destruction or alteration has made a significant contribution to the decline of lichens world-wide (Seaward 1977). The extirpation or decline of these species has been attributed to both cutting of forest, short rotations between timber harvesting, air-quality degradation and slow dispersal and establishment rates of lichen species (Alstrup and Søchting 1989, Broad 1989, Esseen et al. 1981). Rare lichens limited to coastal habitats subject to many different human-caused disturbances, such as *U. hesperina*, are especially vulnerable.

U. hesperina is a rare forage lichen. Conversion of old-growth forests into young managed stands normally leads to a significant reduction in epiphytic lichen biomass, which in turn can have negative consequences for animals that use canopy lichens as food, shelter, or nesting material (Esseen et al. 1996). For example, Pettersson (1995) documented the loss of songbird populations resulting from intensive forestry; short rotations reduced the biomass of lichens that supported insect populations which were the songbirds' primary food source.

Lichens have been known to be sensitive to air pollution for more than a century. Many species in Europe are in an active state of decline because of sulfur dioxide, nitrogen oxides, and acidic deposition of sulfur- and nitrogen-containing pollutants (Ferry et al. 1973, Hawksworth and Rose 1976). Fog contains higher concentrations of dissolved ions and acidity than do rain or snow (James and Wolseley 1992). Lichens that get most of their water from fog and dew, are particularly vulnerable to air-quality and climate changes (Nash 1996). Follmann (1995) documented massive impoverishment and retrogression of lichens over much of the northern Chilean coastal fog belt during the past 20 years. Increasing frequency of El Niño events and gradually increasing aridity were postulated as likely, but not exclusive, causal factors in this decline.

B. Identifying Habitat Areas for Management

All known sites of *U. hesperina* on federal land administered by the Forest Service and BLM in the range of the Northwest Forest Plan are identified as areas where these management recommendations should be implemented. A habitat area for management is defined as suitable habitat occupied by or near a known population.

C. Managing in Habitat Areas

The objective of managing in habitat areas is to maintain the habitat conditions for *U. hesperina*.

Specific known habitat conditions for *U. hesperina* are the foggy coastal headlands, dunes, and wetland mosaics interspersed with pockets of old-growth conifers, Hooker's willow, and other hardwood shrubs. Specific recommendations are to:

- Determine the extent of the local population and habitat area with a site visit.
- Maintain the habitat and associated microclimate of the population.
- Maintain suitable habitat around the current host trees and shrubs, so that the lichen may have adequate new substrate as current substrates decline.
- Like other epiphytes, *U. hesperina* requires retaining groups of standing trees to maintain suitable microclimate and to aid dispersal. Sitka spruce, shore pine, Hooker's willow, and other hardwood shrubs support *U. hesperina* along the immediate coast within 3 km (1-2 mi) of the ocean. Harvesting or thinning trees and removing shrub or other vegetation in the population and the habitat area should be avoided unless these actions would do no harm to, or would improve,

the habitat for *U. hesperina* (e.g., to prevent heavy shading or invasion of weedy, non-host species).
- Develop practices to route human use away from the populations in habitat areas (e.g., divert roads, trails and off-road vehicles). Trampling shrubs or cryptogam mats, compacting roots, damaging trees or branches that serve as substrates, introducing non-native species by seed dispersal or planting, can all adversely affect habitat integrity.
- Prevent fire in the population but utilize or prevent fire in habitat areas, depending on the role of fire in the plant community. Consider recommendations by Christy et al. (1998) for fire management in coastal plant communities.
- Restrict commercial collection of moss, fungi or other special forest products if these activities would adversely affect the integrity of habitat areas.

D. Other Management Issues and Considerations

- Consider opportunities for managing known sites during Forest Plan and Resource Management Plan revisions, such as Botanical Special Interest Areas, Areas of Critical Environmental Concern, or other administratively withdrawn designations, or by prescribing special standards and guidelines.
- Continue to work with state and federal regulatory agencies to protect air quality on federally-managed lands from on- or off-site emissions, especially of nitrogen- and sulfur-containing pollutants.
- Provide information about conserving rare lichens at visitor centers or other locations along the coast to build public support of conservation efforts and to discourage collection of specimens.

V. RESEARCH, INVENTORY, AND MONITORING NEEDS

The objective of this section is to identify opportunities to acquire additional information that could contribute to more effective species management. The content of this section has not been prioritized or reviewed as to how important the particular items are for species management. The inventory, research, and monitoring identified below are not required. These recommendations should be addressed by a regional coordinating staff.

A. Data Gaps and Information Needs

- Revisit known sites to verify the species, determine the extent of the populations, and characterize their habitat conditions.
- Determine if *U. hesperina* meets the criteria for being closely associated with late-successional or old-growth forests.
- Determine the distribution of *U. hesperina* in the range of the Northwest Forest Plan in areas of potentially suitable habitat. Potentially suitable habitat is identified as coniferous forests of exposed foggy coastal headlands and ridges containing mature or old-growth trees, and the stabilized dunes and wetland mosaic interspersed with pockets of old-growth Sitka spruce, shore pine, Hooker's willow, and other shrubs. Areas with potentially suitable habitat are within 5 km (3 mi) of the coast and include Oregon Dunes National Recreation Area and Siuslaw NF lands; coastal BLM parcels, such as those adjacent to Cape Lookout; and other federal land along the coast from northern California to the Olympic Peninsula, Washington.
- Assign priority to Strategy 3 surveys in areas where management treatments or projects are scheduled or proposed on the Siuslaw NF and in BLM parcels along the immediate coast.

B. Research Questions

- What are the dispersal and growth rates of *U. hesperina*? What factors limit dispersal and growth? Which habitat characteristics are necessary for survival of *U. hesperina* propagules?
- Are some conditions unique to late-successional and old-growth forests critical to the survival of this species? How can young managed stands along the immediate coast be managed to conserve and promote populations of *U. hesperina*?
- How should refugial patches be distributed across the landscape to optimize recolonization into managed stands? What are the minimum and optimum patch sizes of colonized habitat necessary to provide for *U. hesperina*?

C. Monitoring Needs and Recommendations

- Monitor known sites for changes in micro-climatic conditions, successional stages, and for inadvertent habitat damage from human activities or wildfire.
- Monitor dispersal patterns and reproductive rates of existing populations.
- Monitor dispersal of existing populations into managed stands.
- Monitor air-quality effects on *U. hesperina*. Evaluate point sources and regional and local urban emissions along the coast in the range of the Northwest Forest Plan. Monitor populations at highest risk.

Usnea hesperina

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