

Management Recommendations for

Lobaria linita (Ach.) Rabenh.

version 2.0

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version 2.0
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 National Forests. It has also been documented on the Wenatchee and Mt. Hood National Forests. 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 and 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.

Management Recommendations for *Lobaria linita*

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 (Jordan 1973). *Lobaria 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

Lobaria 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 1). 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-, P- (Jordan 1973). Tenuorin, methyl evernate, methyl gorphorate, and other substances present (McCune and Goward 1995).

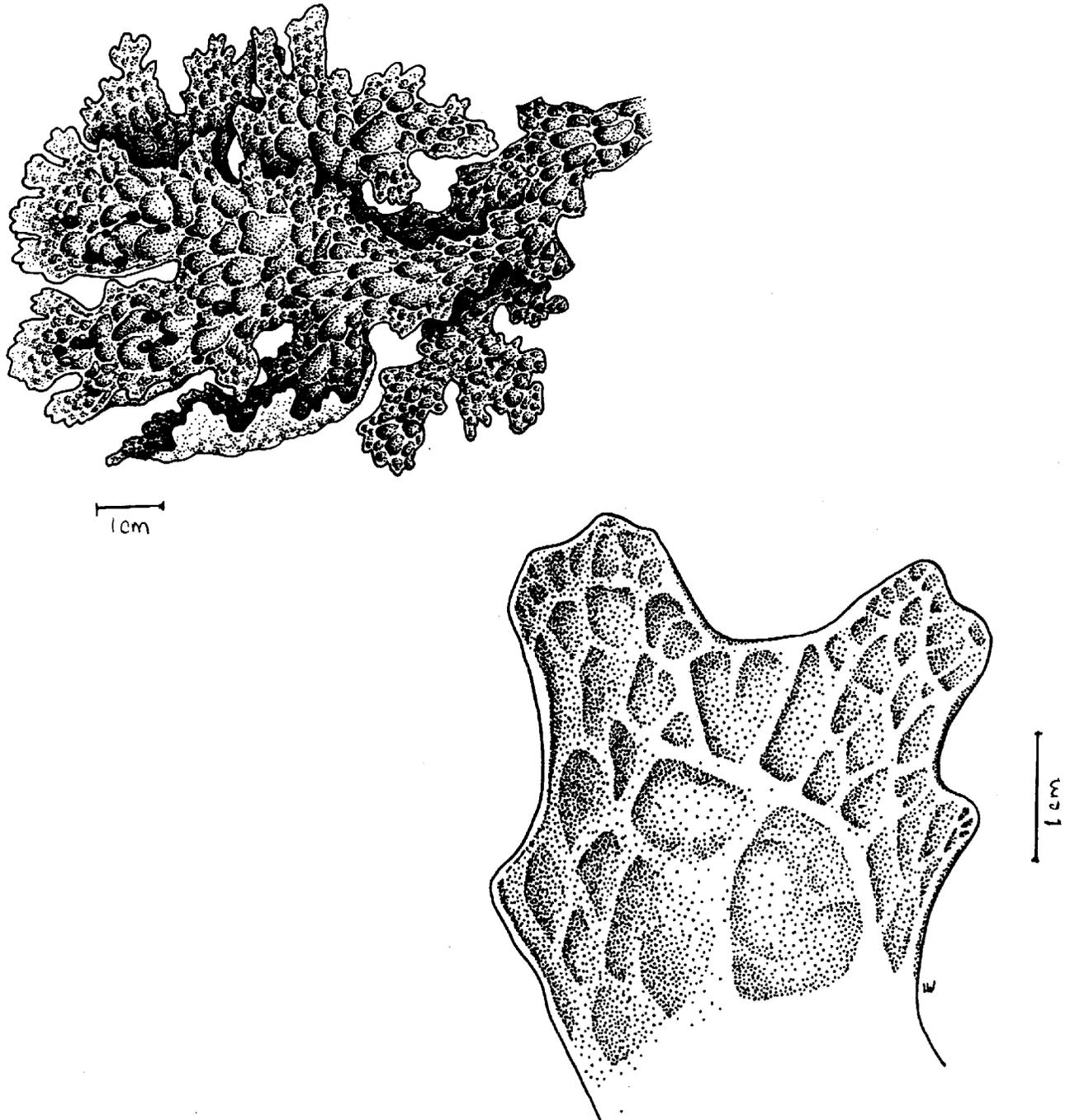


Figure 1. Line drawing of *Lobaria linita* by Alexander Mikulin.

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

Lobaria 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). *Lobaria 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

Lobaria 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.

Lobaria 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. *Lobaria 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 National Forest. 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 National Forest and on the Olympic Peninsula in the Olympic National Forest 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.

Lobaria linita is documented from three sites east of the Cascade crest in Washington on the Wenatchee National Forest. 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 needs to be verified as *L. linita*. Several trips to the Little Sink area to relocate this taxon 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 National Forest (Sillett, pers. comm.), although an outlier geographically, appears to fit the current ecological concept for the taxon. 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 National Forest in California were previously misidentified as *Lobaria 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. *Lobaria 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 percent) known sites of *L. linita* in the range of the northern spotted owl are in northwestern Washington in the North Cascades and Olympic Mountains. *Lobaria 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. *Lobaria linita* is very limited in distribution and appears to be restricted primarily to old-growth and climax forests.

The typical habitat for *Lobaria 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 m and 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.

Lobaria 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 National Forests, more than 80 percent 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 National Forest 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 National Forest, *Lobaria 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 *Lobaria 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*). "*Lobaria 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

Lobaria 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. *Lobaria 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. *Lobaria 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 microclimatic 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 *Lobaria 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 microclimatic conditions associated with *L. linita*.

IV. HABITAT MANAGEMENT

A. Lessons From History

Lobaria 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 National Forests 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 *Lobaria 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 microclimatic 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 National Forests. 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.

Lobaria 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 National Forest, 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—for example, 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 *Lobaria 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 *Lobaria 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 *Lobaria linita* will provide stands to replace those lost to fire, blowdown, or other natural disturbance events.
- *Lobaria 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 body.

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 National Forest.
- 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 *Lobaria 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 taxon of non-forest habitats, then specify management recommendations for the taxon *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 National Forest 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.

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REFERENCES

- Case, J.W. 1980. The influence of three sour gas processing plants on the ecological distribution of epiphytic lichens in the vicinity of Fox Creek and Whitecourt, Alberta, Canada. *Water, Air and Soil Pollution* 14:45-68.
- Databanken for hotade arter och Naturvardsverket 1991: Hotade vaxter i Sverige 1990. Karlvaxter, mossor, lavar och svampar - forteckning och lansvis forekomst. (Sweden's red lists on vascular plants, bryophytes, lichens and macrofungi). Lund.
- Esseen, P.-A., B. Ehnstrom, L. Ericson, and K. Sjoberg. 1992. Boreal forests--the focal habitats of Fennoscandia. pp. 252-325. *In: Hansson, L. (ed.). Ecological Principles of Nature Conservation. Applications in Temperate and Boreal Environments. Elsevier Applied Science, London.*
- Ferry, B.W., M.S. Baddeley, and D.L. Hawksworth. 1973. Air pollution and lichens. University of Toronto Press. Toronto.
- Gilbert, O.L. 1992. Lichen reinvasion with declining pollution. pp. 159-177. *In: Bates, J.W. and A.M. Farmer (eds.). Bryophytes and Lichens in a Changing Environment. Clarendon Press, Oxford, UK.*
- Hawksworth, D. L. 1971. Lichens as a litmus for air pollution: a historical review. *International Journal of Environmental Studies* 1:281-296.
- Hawksworth, D.L. and F. Rose. 1976. Lichens as pollution monitors. *The Institute of Biology's Studies in Biology* no. 66. Edward Arnold, London.
- Jordan, W.P. 1973. The genus *Lobaria* in North America north of Mexico. *The Bryologist* 76(2):225-251.
- McCaffrey, C. Oregon State Office, Bureau of Land Management. Personal communication.
- McCune, B., and T. Goward. 1995. Macrolichens of the northern Rocky Mountains. Mad River Press, Eureka, CA. 208 p.
- Mt. Baker-Snoqualmie National Forest Ecology Program Data Files. Mountlake Terrace, WA.
- Olsen, S.R. and Y. Gauslaa. 1991. *Usnea longissima*, a lichen of ancient forest, threatened in Nordmarka, SE Norway. *Svensk Bot. Tidskr.* 85:342-346.
- Oregon Natural Heritage Program. 1998. Rare, threatened and endangered species of Oregon. Oregon Natural Heritage Program, Portland, OR. 92 p.
- Pike, L. 1978. The importance of epiphytic lichens in mineral cycling. *Bryologist*:81:247-257.
- Rao, D.N. and F. LeBlanc. 1967. Influence of an iron-sintering plant on corticolous epiphytes in Wawa, Ontario. *The Bryologist* 70(2):141-157.
- Rose, F. 1988. Phytogeographical and ecological aspects of *Lobarian* communities in Europe. *Botanical Journal of the Linnaean Society* 96:69-79.
- Sigal, L.L. and T.H. Nash III. 1983. Lichen communities on conifers in southern California Mountains: an ecological survey relative to oxidant air pollution. *Ecology* 64(6):1343-1354.
- Sillett, S. C. Personal communication. Humboldt State University, June 1996.
- Skye, E. and I. Hallberg. 1969. Changes in the lichen flora following air pollution. *Oikos* 20:547-552.
- Tehler, A. 1996. Systematics, phylogeny and classification. pp. 217-239. *In: Nash, T. H. III, (ed.). Lichen Biology. Cambridge University Press, Cambridge, UK.*

- Thor, G. 1990. International Association of Lichenology committee for conservation of lichens red global list. Swedish threatened species unit. Swedish University of Agricultural Sciences, P.O. Box 7072, S-75007, Uppsala, Sweden.
- USDA Forest Service and USDI Bureau of Land Management. 1994a. Final Supplemental Environmental Impact Statement on Management of Habitat for Late-Successional and Old-Growth Related Species within the Range of the Northern Spotted Owl, Appendix A, Forest Ecosystem Management: An Ecological, Economic, and Social Assessment. Portland, OR
- USDA Forest Service and USDI Bureau of Land Management. 1994b. Final Supplemental Environmental Impact Statement on Management of Habitat for Late-Successional and Old-growth Forest Related Species Within the Range of the Northern Spotted Owl, Appendix J2: Results of Additional Species Analysis. Portland, OR. 476 p.
- USDA Forest Service and USDI Bureau of Land Management. 1994c. Record of decision for amendments to Forest Service and Bureau of Land Management planning documents and standards and guidelines for management of habitat for late-successional and old-growth forest related species within the range of the northern spotted owl. Portland, OR.
- USDI, Bureau of Land Management. 1998. Bureau Special Status Species Policy (6840) and Oregon/Washington Special Status Species List, Internal Memorandum OR-98-342, August 28, 1998, including attachments.
- Wetmore, C.M. 1983. Lichens of the air quality Class 1 National Parks. Final Report, National Park Service Contract CX 0001-2-0034. Denver, CO.