

Management Recommendations for
Bryoria tortuosa (G. Merr.) Brodo & D. Hawksw.

version 2.0

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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, *B. 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 National Forest. In Oregon, there are 20 records from the Barlow Ranger District, Mt. Hood National Forest; five records from the Deschutes National Forest, 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: *Bryoria tortuosa* grows on trees in well-lit, open stands, most frequently on oaks and pines, although it has been collected on 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.

Management Recommendations for *Bryoria tortuosa*

I. NATURAL HISTORY

A. Taxonomy and Nomenclature

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

B. Species Description

1. Morphology and Chemistry

Bryoria tortuosa (Brodo and Hawksworth 1977) is a pendent, filamentous lichen, 10-30 (- 40) cm long (Figure 1). 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*. *Bryoria 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

Bryoria tortuosa relies predominantly on thallus fragmentation, a form of vegetative propagation, for reproduction. Sexual reproduction in *B. tortuosa* is presumably rare because of

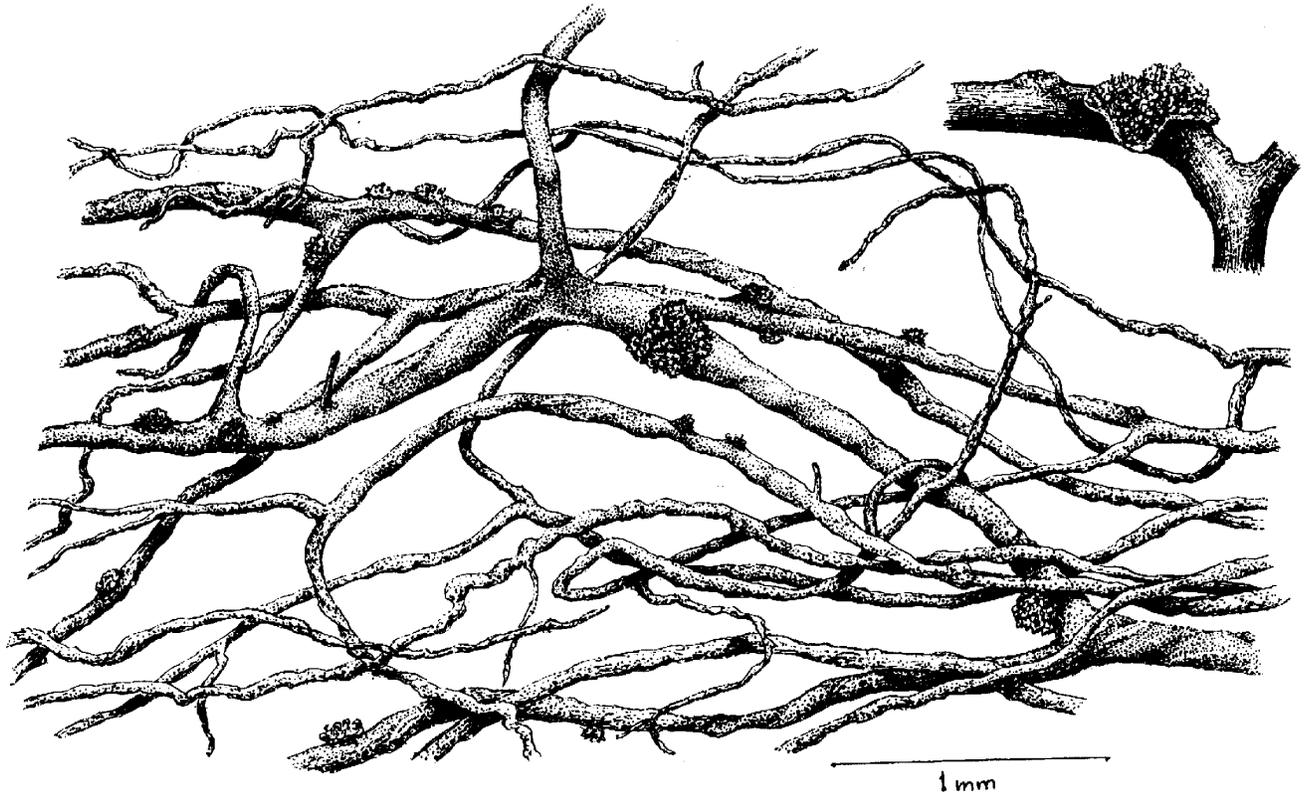


Figure 1. Line drawing of *Bryoria tortuosa* by Alexander Mikulin.

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), *Bryoria 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 (for example, 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

Bryoria 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). *Bryoria tortuosa* commonly grows intermixed with *Bryoria 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

Bryoria 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 National Forest (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 National Forest (Wasco County); and five sites on the Deschutes National Forest, 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 National Forest (Modoc County); Walker Creek Road, Klamath National Forest (Siskiyou County); Weaver Creek, Shasta Trinity National Forest (Trinity County); and two sites near Burney (Shasta County).

D. Habitat Characteristics and Species Abundance

Bryoria 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 National Forest); 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.

Bryoria tortuosa appears well adapted to forests with frequent, natural, low-intensity fires. Most sites on the Barlow Ranger District, Mt. Hood National Forest, 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 National Forest, *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 east slope of the Washington

Cascades. On Barlow Ranger District of the Mt. Hood National Forest, it is particularly common in the Ponderosa Pine-Oregon White Oak/Bitterbrush (*Pinus ponderosa-Quercus garryana/Purshia tridentata*) plant association. *Bryoria 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 National Forest, where the Douglas-fir Zone directly borders the shrub steppe. *Bryoria 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 National Forest. 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 (*P. 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

Bryoria 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. *Bryoria 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 National Forests 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 in east of the Cascade crest in Oregon and Washington. *Bryoria 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 national forests, 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 national forests 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 National Forest. 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 Søbchting 1989, Broad 1989, Esseen *et al.* 1981). *Bryoria 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; 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 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* (for example, 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 body.

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 west side 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.

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