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Estimating the Biomass of Harvestable Epiphytic Moss in Central Western Oregon

Abstract

To address the need for inventory estimates for the nontimber forest product of epiphytic "moss" (a mixture of bryophytes), we inventoried 100 randomly selected 1/8 ha sites in 50-200 year old upland and riparian forests below 915 m elevation in central western Oregon. All commercially harvestable moss was removed from each site, using methods commonly employed by commercial harvesters, and weighed. Although harvestable epiphyte mats were found in 29% of the sites, only 6% had enough moss for the site to be considered harvestable by commercial standards (>50 kg/ha). The commercial moss biomass inventories across all sites, which ranged from 0 kg/ha to 217 kg/ha, are substantially lower than those previously reported for northern Oregon. We examined relationships of harvestable moss occurrence and abundance to environmental variables to facilitate the understanding and prediction of harvestable moss biomass on the landscape. Harvestable moss was most likely to be found in low elevation (<500 m) areas, within 50 m of perennial water, on sites that supported more than 10 m^2/ha in hardwood basal area, and on sites that lacked dry-site shrubs such as *Berberis nervosa*, *Gaultheria shallon*, and *Holodiscus discolor*. Our inventory method is presented and its applicability to other regions is discussed.

Introduction

The importance of commercially harvestable epiphytic "moss" (a mixture of mosses and liverworts; Peck 1997) as a nontimber forest product in the Pacific Northwest has become clearer in recent years. Federal land managers are now faced with writing management guidelines that must balance the demand for the resource and its sustainability. For example, the Suislaw National Forest in Oregon currently issues permits for 50,000 kg (110,000 lbs) of moss per year (USDA 1995) that must be harvested outside of riparian areas, only in the lower canopy, and from "every other stem" in the forest. The Eugene District of the Bureau of Land Management (BLM) in Oregon also prohibits harvest in riparian areas, as well as in Late Successional Reserves (N. Wogen, Eugene BLM, pers. comm.). However, harvest restrictions are currently based on very little information on three critical parameters: (1) the amount of moss being removed from the forests (permit records are scanty, moss buyers are wary about giving information, and illegal harvest is estimated to remove between 2 and 30 times the legal quantity); (2) the actual size of the moss resource available for harvest; and (3) the rate at which mosses re-accumulate following harvesting and long-term impacts on species composition. Information on these parameters is vitally important to guide permitting decisions in the future (Liegel 1992). Some inventory estimates of the moss resource are available from a series of case studies in northern central and western Oregon (Peck and McCune 1998), but inventories are lacking for other areas. Because harvestable moss biomass is extremely variable across the landscape, regional inventories are needed to make informed decisions about commercial moss harvest prescriptions.

The current study, born out of the recognized need for inventory, monitoring, and research in nontimber product programs (USDI 1993), was designed to develop a rapid inventory method that would provide accurate estimates of harvestable moss biomass for sites on the Eugene, Oregon District of the BLM and an Adaptive Management Area (AMA) shared between this District and the Sweet Home Ranger District, Willamette National Forest (WNF). We provide data on biomass and information on site factors that best predict the occurrence or abundance of harvestable moss. We also report the detailed field methods to facilitate similar inventories in other areas where information on the availability of commercially harvestable moss is needed. The epiphyte communities and estimates of harvestable moss mat

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reaccumulation rates are described elsewhere (Peck and Muir 2001).

Methods

Site Selection

The Eugene District of the BLM (including the AMA that it shares with the WNF) lies in central western Oregon between the western foothills of the Cascade Mountain Range and the Pacific Ocean, although most contiguous land parcels lie between the eastern foothills of the Coast Range and the western foothills of the Cascade Range (43°30' – 44°15'N, 122°30' – 123°50'W). A total of 100 sites in predominantly Douglas-fir (*Pseudotsuga menziesii*) stands were sampled. We utilized an established geographic information systems (GIS) database to randomly select management units meeting our requirements. Because high elevation stands and young stands in this region do not support harvestable quantities of epiphytes (J. Peck, pers. obs.), we began by omitting all units above 915 m (3000') in elevation and with forests less than 50 yrs of age. Units of less than 4 ha (10 acres) were excluded to minimize edge effects for a companion study (Peck and Muir 2001). Our intention was to sample representatively across the remaining lands in the Eugene District, thus we calculated the proportion of those lands that belonged to several *a priori* classes: (1) forest land allocation category (matrix, Late Succesional Reserve [LSR], or AMA; [see ROD 1994 for definitions]), (2) either riparian or upland forest (based on the current 61 m [200'] stream buffers set for moss harvest; areas within this buffer were designated "riparian"), and (3) three stand age classes (50-89, 90-199, 3200 yrs). These proportions were then used as weights in a random selection, distributing the number of sites based on the proportional amount of the total land base in each of these classes.

Each site was sampled using a single 35 x 35 m plot (1/8 ha = 1/3 acre; the "whole plot"), which was divided into 49 5x5m "subplots". Thirty sites were sampled in summer 1997 and the remaining 70 sites were sampled in summer 1998.

Site Characteristics

Latitude, longitude, and stand ages for Eugene District sites were obtained from their GIS database and were taken from topographic maps and increment cores for sites in the AMA that is shared with the WNF. Elevation, and horizontal and vertical distance to water, were estimated from topographic maps; when visible the latter was measured on site. In each plot, we recorded: topographic position (1 = bottomland, 2 = lower slope, 3 = midslope, 4 = upper slope, 5 = ridge; these ranks represent an index of decreasing site moisture), aspect, and basal area (BA) of hardwoods and conifers (from averages of wedge prism counts [basal area factor 20] from the plot center and four corners). The presence of major tree and shrub species was also recorded.

Moss, Tree, and Shrub Sampling

We tested a variety of methods for estimating the abundance of harvestable moss in the first five sites, most of which were retained for all sites. However, based on information from the initial sites, we decided to exclude all estimates of moss abundance for conifers, dead hardwoods and dead shrubs from future sites. Conifer boles in this region rarely support harvestable quantities of moss or bear live limbs below 2 m in height, and while dead shrub stems and tree branches may be festooned with moss, it is often too dirty to sell because of the loose, dead bark.

Both whole-plot and subplot estimates (from 10 randomly chosen subplots per plot) were made for the total number of shrubs and trees of species that typically support harvestable moss. These included all species of hardwood trees (e.g., bigleaf maple, *Acer macrophyllum* and red alder, *Alnus rubra)* and mid-to-large size shrubs, such as vine maple (*Acer circinatum*), huckleberry (*Vaccinium parvifolium*), and hazelnut (*Corylus cornuta*), but no low (e.g., salal, *Gaultheria shallon*) or seasonal (e.g., salmonberry, *Rubus spectabilis*) shrubs. Nomenclature follows Hitchcock and Cronquist (1973). Criteria for inclusion in tree and shrub density estimates were: > 1 m tall/long; tree diameters > 4 cm at 1 m in height; shrub diameters > 2 cm at 1 m in length. Vine maple proved to be the host for 95% of samples. Ramets that originated separately from the ground were considered individuals.

Both whole-plot and subplot estimates were made of the number of shrubs and trees bearing "harvestable quantities" of moss, defined according to current commercial harvest standards (following Peck 1997) and including all nonadherant epiphyte mats of at least 200 cm^3 in volume. The total number of these harvestable moss mats, and the number on hardwood trees and shrubs were also visually estimated. All measurements and estimates of moss mats were taken only in the lower 2 m of the canopy, which are typically subject to legal commercial moss harvest on public lands (e.g., USDA 1995). All subplot-level estimates were extrapolated to the whole- plot level by multiplying their average values across the 10 subplots by the total number of subplots. Raw data are given in Peck and Muir (1998, 1999).

All commercially harvestable moss was then removed from each whole plot, below the 2 m height cutoff, according to methods commonly used by commercial moss harvesters (various commercial moss harvesters, pers. comm.). Harvestable moss from trees and shrubs was kept separate. All material was packed into burlap bags for transport, allowed to air dry for a few days, and then weighed. To calibrate air-dried weights to oven-dried weights for large-volume samples, several subsamples from each site (~25% of total volume) were weighed air dried, then oven dried (24 hrs @ 60 C), and reweighed. A correction factor for water content (oven-dried weight/air-dried weight) was then applied to the rest of the air-dried moss from that site to calculate the total oven-dried weight of harvestable moss from each site.

Data were collected at both whole- and subplot levels in a total of 30 sites during summer 1997. However, during summer 1998, the final 70 sites were sampled only at the whole-plot level, as we had concluded that whole plot-based estimates were comparably accurate, and yet substantially (2-3 times) less time consuming than those derived from subplot sampling (Peck and Muir 1998).

Data Analyses

Associations between actual abundance of harvestable moss (oven-dried biomass) and individual quantitative site characteristics, including whole-plot estimates of host density and number of harvestable mats, were assessed using Pearson correlation analyses (PROC COR, SAS 1996). Harvestable moss biomass data were squareroot or natural log transformed, after scatter plots were examined, to improve normality prior to analysis. Only associations with $P \leq 0.05$ are reported here, however caution should be used when interpreting p-values, given that multiple comparisons were made.

We sought to develop regression models capable of predicting the abundance of harvestable moss (oven-dried biomass; squareroot or natural log transformed), with candidate predictor variables chosen based on the four sets of assumptions listed below. We used multiple linear regression (PROC GLM, SAS 1996), on all possible variable combinations and retained only variables with P-values ≤ 0.05 in the final models. Along with quantitative site variables, indicator variables for the upland and riparian and for AMA, LSR, and matrix site designators were tested, but were never retained in final models.

Several regression models were derived, based on all 100 sites (including those with no harvestable moss) using four sets of assumptions about what information might be available for future predictions. These assumptions were:

1. Only the current BLM GIS database information is available (e.g., elevation, stand age, latitude, longitude, horizontal and linear distance to water, Coast/Cascade Range classification).
2. The assumptions from #1 above *plus* presence/absence information for major tree species (potentially available without on-site measures).
3. The assumptions from #2 above *plus* presence/absence information for major shrub species (potentially available without on-site measures).
4. The assumptions from #3 above *plus* additional site characteristics (e.g., aspect, topographic position, and basal area estimates) and the whole-plot estimates of host and moss mat density (require on-site measures).

In addition to these tests for linear (or linearizable) relationships between oven-dried biomass and site variables, we tested whether mean biomass (squareroot transformed) differed among sites of various discrete types using simple one-way ANOVA's with F-tests (PROC GLM, SAS 1996). We compared mean biomass values among the three land allocations (matrix, LSR, and AMA), between riparian and upland sites, and among the three forest age classifications.

Finally, in addition to analyses focusing on abundance of harvestable moss (biomass), we asked whether its occurrence (presence or absence) was independent of various site characteristics. We used the chi-squared test for homogeneity to test independence of harvestable moss occurrence from site characteristics, and an odds tests (Ramsey and Schafer 1997) to calculate the associated probabilities of finding harvestable moss given various site conditions.

Results and Discussion

Biomass Estimates, Distribution, and Prediction

Of the 100 randomly selected sites, 71% had no or virtually no harvestable moss (e.g., < 2 kg/ha; Table 1). Commercial moss harvesters generally consider sites desirable if they support more than the equivalent of approximately 50 kg/ha oven-dried biomass (various harvesters, pers. comm.). Only 6% of our sites supported more than this, with 23% of sites having more than 80 mats/ha but less than 50 kg/ha. Averaging 10 kg/ha (sd 33 kg/ha) across the 100 sites, the study area would appear to have too little commercially harvestable moss to sell. However, continued requests for harvest permits on the Eugene District probably reflect the fact that some sites support biomasses over 200 kg/ha (Table 1), and that the average of 36 kg/ha (sd 55 kg/ha) in the 29 sites where harvestable moss was present is close to "desirable" from a commercial perspective, particularly when harvestable moss is scarce in the area.

Both the average and the range of observed biomasses are substantially lower than those reported for the Hebo District, Siuslaw National Forest in northwestern Oregon (45°2' – 45°13'N, 123°5' – 123°55'W), which receives the bulk of moss harvest activity in Oregon and supports biomasses ranging from 119 to 1469 kg/ha, averaging 550 kg/ha (Peck and McCune 1998). The sites on the Hebo District, however, were not selected randomly, but were sought out as mossy examples of that area, which is situated in a fog belt on the western edge of the Coast Range less than 50 km from the Pacific Ocean. In contrast, much of the Eugene District lies in the rain shadow of the Coast Range mountains in the Willamette Valley, and drier portions of the foothills of the Cascade Range.

Somewhat more comparable, therefore, are sites in the northwestern foothills of the Cascade Range of Oregon (44°30' - 45°20'N, 122°12' - 122°35'W), which, although chosen with a bias for hardwoods and riparian areas, were chosen independently of harvestable moss (Peck and McCune 1998). These sites also had higher harvestable moss inventories (average = 385 kg/

TABLE 1. Descriptors of actual harvestable moss biomass (oven-dried) and key environmental variables for the 100 sites in this study. Data are broken down by site biomass categories: sites with < 2 kg/ha and sites with ≥ 2 kg/ha oven-dried biomass. N = number of sites in each category. BENE = *Berberis nervosa*, GASH = *Gaultheria shallon*, HODI = *Holodiscus discolor*.

	Sites With ≥ 2 kg/ha Moss (N=29)		Sites With < 2 kg/ha Moss (N=71)	
	Mean (st.dev.)	Range	Mean (st. dev.)	Range
Harvestable moss biomass (kg/ha)	36 (55)	2.2 - 217	0	–
Elevation (m)	204 (127)	65 - 634	405 (238)	93 - 957
Horizontal distance to water (m)	47 (64)	7 - 305	177 (204)	15 - 762
Vertical distance to water (m)	12 (14)	0 - 60	44 (60)	0 - 305
Conifer BA (m^2/ha)	22.4 (13.4)	0 - 46	32.9 (15.1)	8 - 76
Hardwood BA (m^2/ha)	7.9 (9.4)	0 - 41	3.7 (5.5)	0 - 26
	% of sites		% of sites	
Sites with BENE	45		76	
Sites with GASH	38		80	
Sites with HODI	21		45	
Stand Age Class				
50 – 89 yrs	41		54	
90 – 199 yrs	38		18	
≥ 200 yrs	21		28	

ha; range from 24 to 1068 kg/ha) than we found in the Eugene District, which probably reflects the somewhat wetter conditions of the area just north of ours. Peck and McCune (1998), however, visited a total of 20 sites in that area with no restrictions on elevation or stand age, and these values reflect the 10 sites that had some harvestable moss; excluding sites over 915 m in elevation and younger than 50 yrs in stand age, they found harvestable moss in 71% of their sites (Peck 1996).

The riparian and upland classifications used in this study were sensitive enough to detect the higher probability of harvestable moss occurrence in riparian as opposed to upland areas (chi-squared test, $P < 0.001$) but not enough to detect the magnitude of differences in biomass (Table 2; ANOVA, $P > 0.5$). The high variability in moss biomass that results in this lack of sensitivity reflects, at least partly, the fact that the 61 m buffer, designed to protect riparian communities from the impacts of commercial moss harvest, is probably broader than the microclimatic zone that influences the development of epiphytic bryophyte biomass. Harvestable moss was most likely to be found less than 50 m from water (chi-squared test, $P <$ 0.03), and no harvestable moss was found more than 300 m in horizontal distance from a perennial body of water or stream, as reflected in the negative correlation between horizontal distance and biomass (Tables 1, 3), Thus, although the 61 m buffer is likely sufficient to protect the riparian communities in the study area from the impacts of commercial moss harvest, it is not so useful in predicting the actual biomass of harvestable moss.

TABLE 2. Oven-dried biomass means (and standard deviations) for sites of various types (see Methods for descriptions). Total number of sites = 100. N = number of sites of each type. F and P – values are from simple one-way ANOVAs on biomass (squareroot transformed).

Site Type	Oven-dried biomass (kg/ha)	N	F	P
Topographic Position			0.85	0.67
Riparian	13.8 (37.5)	56		
Upland	5.7 (27.1)	44		
Land Allocation			0.64	0.53
Matrix	8.1 (35.9)	38		
LSR	6.0 (20.9)	43		
AMA	24.3 (47.0)	19		
Stand age class			0.64	0.53
50-89 yrs	11.9 (37.1)	51		
90-199 yrs	16.6 (41.4)	24		
≥ 200 yrs	1.1 (2.3)	25		

TABLE 3. Pearson correlations (and associated two-tailed P – values) between oven-dried biomass (squareroot transformed) and site variables across all 100 sites.

Site Variable	r	P
Horizontal distance to water (m)	-0.24	0.015
Vertical distance to water (m)	-0.26	0.009
Elevation (m)	-0.33	< 0.001
Conifer BA (m^2/ha)	-0.28	0.005
Hardwood BA (m^2/ha)	0.23	0.02

Difficulty in predicting biomass arises partly from the complex nature of the microclimatic conditions that are conducive to epiphytic bryophyte growth, which we are only now beginning to understand. Because mosses can absorb water directly from the air, humidity is an important environmental factor. In addition to horizontal distances from water, vertical distances are also important. No harvestable moss was found more than 60 m in vertical distance from water (Table 1), and it was most likely to occur within 30 m (chi-squared test, $P < 0.003$), although the pattern was already discernible at 50 m (chi-squared test, $P < 0.01$). Vertical distance to water was negatively correlated with harvestable moss abundance (biomass) as well (Table 3). The importance of distance to water is further illustrated by the fact that, despite the small sample size of high-biomass sites, sites with more than 50 kg/ha of harvestable moss were most likely to be found less than 30 m and 20 m in horizontal and vertical distance from water, respectively (chi-squared test, $P < 0.05$). However, humidity is not only influenced, or reflected, by distance to water, nor is it the only relevant environmental characteristic for epiphytic bryophyte growth, as evidenced by the fact that, of the 45 sites within these distances to water, only 40% had harvestable moss, while 20% of the remaining 55 sites also had harvestable moss.

Even within our restricted range, elevation was negatively correlated with harvestable moss biomass (Table 3; also see Table 1), with harvestable moss most likely to occur below 500 m in elevation (chi-squared test, $P < 0.03$). Conifer basal area was negatively correlated with harvestable moss biomass, while biomass and hardwood basal area were positively correlated (Table 3; also see Table 1), which is in keeping with previous findings (Peck 1997). No harvestable moss was found in sites with fewer than 40 hardwood trees per hectare, and harvestable moss was most likely to be found in stands with more than 10 m^2/ha in hardwood basal area (chi-squared test, $P < 0.001$). Indeed, the positive association between harvestable moss occurrence and hardwoods was detectable with as little as 1 m^2/ha of hardwood basal area (chi-squared test, $P < 0.005$).

Several species of understory shrubs were negatively associated with harvestable moss biomass (Table 1), including salal, Oregon-grape (*Berberis nervosa*), and ocean-spray (*Holodiscus discolor*). Harvestable moss was more than 6 times more likely to occur in sites without salal as in those with it (odds test, $P = 0.0005$; 95th percentile confidence interval from 3 to 17). Similarly, harvestable moss was 3 (1 to 8) times and 4 (2 to 10) times more likely to occur in sites without ocean-spray and Oregon-grape, respectively (odds test, $P = 0.0025$). Both salal and ocean-spray are considered to be indicative of relatively dry conditions within our study area (Franklin and Dyrness 1973). In contrast, harvestable moss was nearly 3 (1 to 7) times more likely to occur in sites that supported the riparian hardwood tree, red alder (odds test, $P = 0.025$).

No differences in harvestable biomass were detected among the stand age classifications (Table 2). We also found no association between stand age and the density of harvestable moss-harboring (or potentially harboring) host shrubs. Stand age, it seems, may not be as important for the development of epiphytic bryophytes as the availability of large host shrubs, which are positively associated with the occurrence of large epiphytic mats in our area (Rosso 2000). Thus it is not surprising that no distinction in harvestable moss biomass was discerned across the three land allocations (matrix, AMA and LSR; Table 2), as sites within each allocation occur across a wide range of environments and stand ages. These land allocations, although useful for other aspects of land management, cannot be used to predict the presence of harvestable moss across the landscape.

The regression analyses, in general, did not allow us to account for more variation in harvestable moss biomass than was accounted for by the simple correlation analyses. Only three significant ($P \leq 0.05$) models resulted from our four sets of assumptions about data availability (see Methods). Based only on information currently available in the BLM's GIS database, the best model included only elevation (biomass decreasing with increasing elevation), and, while statistically significant, it had low predictive power ($R^2 = 0.11$). When the presence or absence of major tree species was included in variable selection, once again only elevation was retained (i.e., the model was identical to the previous model). We discovered, however, that the presence or absence of two shrub species, salal and Oregon-grape, was a better predictor of harvestable biomass than elevation. When these were included in variable selection along with variables available in the GIS database and the presence or absence of major tree species, the best model included only these two shrub species (partial r^2 for salal = 0.11; for Oregon-grape partial $r^2 = 0.13$; model $R^2 = 0.24$), with harvestable biomass decreasing when they were present. Not surprisingly, the inclusion of whole-plot measures produced the best model, but again retained only one variable: the log of the estimated number of harvestable moss mats present on shrubs in the plot (biomass increasing with increasing number of mats, $R^2 = 0.57$).

Harvestable Moss Inventory Methodology

Data availability assumptions

In terms of predictive power, it is clear that harvestable moss biomass can be predicted better when whole-plot measures are available than when only GIS database and shrub and tree distribution information are available. Inventory estimates based solely on the data currently available in these databases would be inadequate to predict accurately the biomass of harvestable moss. However, it is unlikely that the extensive on-site surveys required for obtaining whole-plot estimates of mat numbers will prove practical for the Eugene District or for other, similar land management agencies.

Fortunately, the elevation and distance to water cutoffs addressed earlier, as well as information on the distribution of salal, ocean-spray, and Oregon-grape, can be used to predict which areas of this district are most likely to harbor some harvestable moss. Specifically, based on the sampling conducted in the current inventory, probabilities of harvestable moss occurrence can be calculated for various combinations of these variables. For our area, sites above 500 m in elevation and more than 50 m of horizontal and 30 m of vertical distance from water (all variables available in many current GIS databases) would be 6.6 times less likely to harbor harvestable moss than lower elevation sites closer to water; a substantial enough reduction that managers could assume that essentially no harvestable moss will be found in those areas. If we exclude these unfavorable areas, which constitute 65% of the area of the Eugene District, and apply the average biomass estimate for sites within these elevation and distance-to-water constraints (11.8 kg/ha) to the rest of the Eugene District, we can estimate a harvestable moss inventory (oven-dried) of roughly 523,963 kg (1,152,720 lb) on the District as a whole, 261,136 kg (574,500 lb) of which is on matrix lands and hence currently open to commercial harvest. If the distributions of salal, ocean-spray, and Oregon-grape were available, a site known to have one of these three shrubs would be 6.7 times less likely to harbor harvestable moss than sites without these shrub species, potentially excluding these sites from moss production estimates (and hence lowering the estimates given above).

With such a low biomass inventory and slow estimated re-accumulation rates (more than 20 year rotation periods are indicated for this area; Peck and Muir 2001), it appears to be unwise to permit moss harvest on this district. Not only would the costs of issuing permits and enforcing harvest regulations exceed permit fee revenues for the few harvesters willing to purchase a permit, but sustainable harvest would dictate very low levels of allowable harvest and long rotation periods.

Methodology

The harvestable moss inventory method described here, involving whole-plot harvest of randomly selected sites, can be reproduced in other moss-scarce areas with few modifications. On-site plot layout and measurements of site characteristics at the whole-plot level typically required 1/2 hr to complete, with whole-plot shrub and mat density estimates requiring another 1/2 hr and moss harvest taking an additional 0-60 min. Distances between sites were relatively large, often requiring over an hour of driving time, plus additional time to access the site. Thus, at most three to four sites could be sampled per day. The time required to conduct such an inventory using the whole-plot harvest method would likely be similar throughout southern central and western Oregon and northern California. Sampling in northern Oregon, and western Washington and British Columbia, however, would require substantially more time due to the higher biomass of harvestable moss present in these areas.

In addition to the biomass inventory estimates that could be obtained, an approximately comparable predictive ability could probably be derived from the resulting dataset. This would enable the development of predictive regression models and the calculation of presence/absence probabilities for sites based on key environmental variables (e.g., elevation, distance to water, or the presence of key shrub species) that could be applied to non-sampled portions of the study area. We encourage other researchers and forest managers to consider the environmental variables that we discovered to be important predictors, as this may facilitate their development of models for predicting occurrence or abundance of harvestable moss without the need for intensive on-site measures after the initial sampling.

Summary

- Our estimates of harvestable moss biomass (0 to 217 kg/ha, with many sites lacking harvestable moss) are substantially lower than those recorded for wetter northern Oregon.
- The Federal land allocations of matrix, LSR, AMA, and even the designations of "riparian" and "upland" based on moss harvest restrictions, were unrelated to biomass of harvestable moss. These classifications can not, therefore, be used to predict moss biomass, and generalizations across these land classifications as to the available biomass of harvestable moss are not appropriate.

- In central western Oregon, harvestable epiphytic moss is not likely to be found at elevations greater than 500 m, more than 50 m from perennial streams, or in drier sites that are indicated by the presence of *Berberis nervosa*, *Gaultheria shallon*, or *Holodiscus discolor*.
- The low frequency and biomass of harvestable moss found in this study suggests that, to protect the ecosystem functions of the few mossy sites that do exist, no permits for harvesting moss should be issued on the Eugene District.
- The whole-plot inventory method presented here is suitable for other areas in southern central and western Oregon, where harvestable moss is relatively scarce.

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