An Assessment of Commercial "Moss" Harvesting from Forested Lands in the Pacific Northwestern and Appalachian Regions of the United States: How Much Moss is Harvested and Sold Domestically and Internationally and Which Species are Involved?

Final Report to U.S. Fish and Wildlife Service
and
U.S Geological Survey, Forest and Rangeland Ecosystem Science Center

Review draft submitted May 20, 2004

Final Report submitted August 17, 2004

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Abstract

The work reported here addressed three primary questions: (1) How much "moss" (a mixture of mosses and liverworts) is harvested commercially from forests in the Pacific Northwestern (PNW) and Appalachian regions of the U.S.? (2) What percentage of the harvest is exported out of the U.S.? (3) What species are included in harvests, and are any species of concern? Methods included surveying land managers, botanists, and moss dealers, querying official U.S. government databases, interviewing individuals involved in the moss trade, and identifying species found in purchased samples of moss products. Approximately 35% of land manager respondents have issued permits for moss harvest in the last 5 yrs, and these reported that permits were issued for an average of 4,009 (Appalachian) and 96,433 (PNW) air dry kg of moss over the years 1997-2002, with a maximum reported permitted harvest of 166,793 air dry kg across both regions in the year 2000. Official U.S. Forest Service sources listed the maximum yearly reported harvest as 115,661 air dry kg in 2000 (PNW = 71,534 kg and Appalachians = 44,127 kg) and official Bureau of Land Management sources for OR and WA listed the maximum permitted harvest as 54,978 air dry kg in 2001. Yearly revenues from commercial moss harvest permit sales were reported to be $\leq$ U.S. $19,650. By contrast, estimates of total harvests based on export data and a set of assumptions about those data suggest that the mean yearly harvest for the years 1998 – 2003 was between 4.6 and 18.4 million air dry kg (yearly maximum and minimum estimated at 37.4 million and 0.9 million air dry kg, respectively). Moss sales (domestic plus exports) are estimated to be between U.S. $6 million and $165 million per yr. Five to six species comprise most of the harvest in each region, however many "incidental" species are included. None of the species included in purchased samples are listed as species of concern, however our sample of purchased products was relatively small (N = 54), leaving open the possibility that sensitive species would be found in a larger sample. Recommendations for enhancing the economic and ecological sustainability of commercial moss harvesting are provided.

Executive Summary

Forest bryophytes (mosses and liverworts, hereafter, "moss") are a nontimber forest product whose commercial importance is increasing. However, little is known about how much harvest is legally permitted, how much is actually being harvested, how harvest rates compare to reaccumulation rates, and whether species of concern are harvested. In addition, while the importance of moss in forest ecosystems is widely acknowledged, no studies have addressed whether commercial harvest has an impact on any of these ecosystem functions. Informed management of this resource depends on answers to these questions. We focused on moss harvest in the Pacific Northwestern (PNW) and Appalachian regions of the US, surveying land managers, botanists, and moss dealers for information and opinions on moss harvest issues. We also purchased moss from a variety of outlets, and sent the material to bryologists for species identifications. Approximately 48% of 372 land managers, 51% of 88 botanists, and only 21% of 105 businesses responded to surveys. Thirty five percent of land manager respondents indicated that they had received requests to harvest moss commercially from their lands within the past 5 yrs, and these reported that permits were issued for 87,740 kg (air dried) of moss in 2002. More harvest permits were issued for lands in the PNW than in the Appalachians, and reported harvest quantities were also larger for PNW lands than for Appalachian lands. Reported harvest quantities are conservative estimates of total harvest for several reasons. (1) Some land managers allow harvesting without permits or allow unlimited harvest under a permit. (2) Some land managers do not maintain records on numbers of permits granted or quantities of harvest allowed. (3) Many land managers indicated that illegal harvesting is widespread and probably accounts for more harvest than is legally permitted. (4) Our sample of land managers was incomplete, in part because many did not respond to surveys. Estimates based on export data suggest that the value of moss exports from the U.S. over the past 6 yrs has ranged between U.S. $ 16.5 million and 1.1 million. These dollar values convert to an estimated 0.17 to 3.7 million kg (air dried) per yr of moss exports. Least well resolved were domestic sales quantities, as most dealers would not divulge sales information. We estimated total domestic sales quantities conservatively, based on export data, ratios of domestic to international sales provided by moss dealers and other assumptions; the resulting estimate for domestic sales was between 0.7 million and 33.7 million kg (air dried) per yr over the past 6 yrs. The sum of estimated total domestic and export sales quantities gave yearly totals between ~0.87 million and 37.4 million kg (air dried) kg per yr over the past 6 yrs, quantities that are orders of magnitude greater than reported permitted harvests. Approximately 64 % of botanist respondents believed that current harvest volumes are of concern, but only 16 % of land manager respondents believed that harvest regulations are not sufficiently protective of the resource. Most of the moss samples that we purchased were comprised primarily of three to seven species, however many "incidental" species were also included. The 34 samples from the PNW contained a total of 34 moss and liverwort taxa, while a total of 28 moss and liverwort taxa were found in the 20 samples of Appalachian material. The most prevalent species in PNW material included *Antitrichia curtipendula, Eurhyncium oreganum, Isothecium myosuroides/spiculiferum, Porella navicularis* and *Rhytidiadelphus loreus,* while the most prevalent species in Appalachian material included *Dicranum scoparium, Hypnum curvifolium, H. fertile, H. imponens, H. cupressiforme,* and *Thuidium delicatulum.* No species of special concern were found in either the PNW or Appalachian material, however species composition of harvested material should be monitored over time, as sensitive species may be included in some harvests.

Recommendations that could enhance sustainable management of the moss harvest industry are provided, and include the following:

- Obtain information on the size of the commercial moss resource and its reaccumulation rate and species composition.
- Conduct inventories and monitoring with moss harvester cooperation.
- Educate harvesters and, reciprocally, learn from harvesters about harvest techniques that are most sustainable. Include training in recognition of sensitive species, and about why it is important to avoid harvesting certain species and in sensitive habitats.
- Conduct additional research on ecosystem roles provided by mosses and assess whether commercial harvesting adversely affects any of these functions.
- Analyze communities of species associated with moss mats to determine whether interstate or international transport of untreated moss may cause introductions of species that could become problematic.
- Explore the possibility of cultivating mosses for commercial purposes.
- Improve tracking of and record keeping on harvested quantities and locations, and standardize reporting formats.
- Facilitate tracking of quantities of moss being sold domestically and by export by assigning unique codes to forest moss.
- Couple moss harvest permitting with a commitment by the land management agency to monitor periodically the resource to assess effects of harvesting.
- Include standards and guidelines for moss harvest in National Forest Plans and similar planning documents for other land management agencies.
- Include management for the moss resource in silvicultural prescriptions.
- Identify and protect from harvest areas known to host concentrations of sensitive species or that comprise particularly sensitive habitats.
- Improve enforcement of harvest regulations.
- Explore the utility of alternative arrangements for allowing harvester access to sites where harvest is deemed acceptable.
- Approach regulation of moss harvest on a regional, rather than land-management unit, scale.

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Introduction

The research reported here focused on gathering and summarizing available information on the commercial harvest of forest "moss," a non-timber forest product (NTFP), whose commercial importance has increased greatly over recent years. (As used here, "moss" includes both moss and liverwort species.) Despite the commercial importance of this product, relatively little is known about sustainable and actual rates of harvest, which makes it impossible for land managers and regulators of moss trade to write and enforce ecologically-sound harvest or export regulations. In addition, while moss harvest is regulated from some forests, it is not regulated on other forest lands, and illegal harvest has been estimated to remove as much as (or more than) legal harvest from lands where the harvest is regulated. Information on *actual* harvest rates and the fate of harvested material (e.g., proportions sold domestically *versus* exported) is lacking for moss (as for most other NTFPs), but is needed if the resource is to be managed sustainably. Finally, information on the species being harvested is needed; if species of concern are included in harvests, additional regulation of the harvest may be necessary.

The work reported here addressed four basic questions:

(1) How much commercial harvest of moss is allowed by permit from Federal lands (e.g, those managed by the U.S. Forest Service, Bureau of Land Management) and from non-Federal lands (e.g., state and private timber lands), and under what harvest guidelines,
(2) How much moss is sold domestically and internationally,
(3) Does this quantity (from #2) differ significantly from estimates of quantities harvested with formal permits (from #1), suggesting that harvest from lands that do not require permits or illegal harvest is extensive, and
(4) What species are most commonly included in the harvested material, and are any of these species of special concern?

The focus of the work was the Pacific Northwest of the US (PNW) and the Appalachian region; areas from which most commercial harvest of forest mosses comes.

Background and Need for the Work

A wide variety of products other than timber is harvested for commercial purposes from forests in the U.S. (see recent overview in Jones et al. 2002). The USDA Forest Service (USFS) defined such products that are not timber-based as "special forest products," (USDA 2001), however the term "nontimber forest products" (NTFPs) is more widely used (Chamberlain et al. 2002), and will be used here. While harvest of NTFPs for commercial purposes has taken place for decades, or even centuries in some cases (Nelson and Williamson 1970; Douglas 1975; Freed and Davis 1997; Blatner and Alexander 1998; Emery 2002), only recently has much attention has been paid to the trade. Most assessments have focused on business involving edible mushrooms (e.g., Schlosser and Blatner 1995; Pilz et al. 1999;Alexander et al. 2002a); or floral greens, Christmas boughs, and medicinal herbs (e.g., Schlosser et al. 1991, 1992; Blatner 1997; Blatner and Schlosser 1997; Blatner and Alexander 1998; Kauffman et al. 2000; Alexander et al. 2002b; Chamberlain et al. 2002; Greenfield and Davis 2003). These, and other, assessments

variously consider economic and ecological aspects of NTFP harvest and sales, and commonly find that it is difficult to obtain reliable, quantitative data on amounts being harvested, numbers of people involved in various aspects of the businesses, prices being paid, total value of the products, sustainable rates of harvest, and potential ecological impacts of harvest (e.g., Vance and Thomas 1997; Alexander et al. 2002b). These unknowns for U.S. NTFP industries, as well as for related industries in other nations, led to the Working Group on Criteria and Indicators for the Conservation and Sustainable Management of Temperate and Boreal Forests for the Montreal Process (to which the U.S. is a signatory) citing lack of adequate information about NTFPs as an important gap in knowledge upon which to judge sustainability of forest management (McClain and Jones 2002).

Increasing attention has focused in recent years on commercial harvest of "moss" (typically a mixture of mosses, liverworts, and some lichens; Peck 1997a) from both economic and ecological perspectives. Harvested moss is sold within the US and is exported, largely for use in the florist/horticulture trade (e.g., Blatner 1997; Mater 1997; Robbins 1997; Vance and Thomas 1997; Alexander et al. 2002b). Federal land managers and others involved with regulating harvest and trade of mosses, and other NTFPs, are faced with writing management and trade guidelines that balance: a) demand for the resource, b) multiple-use mandates for many forested lands, c) protection for species of concern, d) concerns about sustainability of harvest, e) socioeconomic considerations, particularly related to income opportunities in economically-depressed rural areas, and f) potential threats to ecosystem functions that are provided by moss. However, in addition to a lack of information on socioeconomic aspects of the harvest trade, little to no information is available on at least four additional and critical parameters:

1) the quantity of moss available for harvesting,
2) the amount of moss actually being harvested,
3) species included in harvests,
4) the rate at which moss reaccumulates after harvest, and
5) the long-term impacts of harvesting on species composition and ecosystem functions associated with forest mosses.

Information on all of these parameters is needed to guide permitting and trade decisions in the future (Liegel 1992; USDI 1993; USDA 1995; Freed and Davis 1997; Peck and McCune 1998; von Hagen and Fight 1999; USDA 2001; Peck and Muir 2001a, 2001b; Alexander 2002; Antypas et al. 2002; Chamberlain et al. 2002; Jones et al. 2002; Kerns et al. 2002; Duncan 2003; Greenfield and Davis 2003).

Recent work from Oregon is beginning to fill some gaps in our understanding, particularly for parameters 1,3, and 4 (above). This work suggests that the quantity of moss available for harvesting is highly variable region-to-region, even within western Oregon (Peck and Muir 2001a) and that reaccumulation rates are slow (harvest rotation lengths of upwards of 21 years are indicated (Peck and McCune 1998, Peck and Muir 2001b). Long-term monitoring projects initiated in the PNW (Vance et al. 1997; Peck and McCune 1998; Peck and Muir 2001b; Hutten et al. 2001) and in the Appalachians (Kauffman et al. 2000; Studlar 2003) will yield additional insights on rates and species composition of post-harvest regrowth, and these should help guide management towards developing effective guidelines for sustainable commercial moss

harvesting. Early results from these monitoring studies suggest that, if commercial harvesting is to be sustainable, even in the "mossy" PNW, it must be carefully regulated.

Some information, much of it unpublished, is also available on the species composition of harvested material from the PNW (e.g., Peck 1997a, 1997b; Vance and Kirkland 1997; Hutten et al. 2001; Peck and Muir 2001b) and the Appalachians (Studlar 2003; Kauffman and Davison *in prep.*), but a systematic review of species found in commercially available moss products has not, to our knowledge, been completed prior to this study. In addition, some experimental work has measured growth rates for a small number of commercially-important moss species in the PNW (Rosso et al. 2001; Muir et al. *in prep.*), but we are not aware of similar information from other regions in which commercial harvesting occurs, nor do we understand the degree to which inferences from transplant studies can be extended to naturally-occurring mosses. Given that some bryophytes are species of concern (e.g., listed as "survey and manage" species on lands within the area encompassed by the Northwest Forest Plan [USDA and USDI 2003]), and that some of these species are likely being harvested and sold domestically and internationally, species-level harvest information is needed to ensure that harvest and trade are regulated appropriately.

Information has been almost completely lacking on the total quantity of moss being harvested commercially from federal or other forested lands in the US. Some Federal agencies, such as the USFS and Bureau of Land Management (BLM) do maintain some records on how many permits for commercial moss harvesting they grant per year, or on how much moss harvest these permits cover (USDI BLM 1997, 2001; www.fs.fed.us/forestmanagement/reports/sfp/index.shtml). For example, the Siuslaw National Forest in western Oregon issued permits for the harvest of ~ 50,000 kg [air dried weight] of epiphytic moss per year during the 1990's (USDA 1995). However, no systematic survey has previously been conducted to summarize permit records from Federal, state and private land management agencies (including corporations) in the PNW or in the Appalachians. Anecdotal information suggested that many agencies either allow harvest without permits or do not maintain permit records, and further that a considerable amount of moss is harvested illegally. There is a great need for information on quantities being harvested and sold (both for the resource overall and for individual species), so that regulators of harvest and trade can develop appropriate resource management, monitoring and permitting processes.

A portion of harvested moss is exported, however data on export quantities have not previously been summarized. If exported quantities are large and threaten the sustainability of the resource or of individual species, it may be necessary to list vulnerable mosses under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES; http://www.cites.org). This convention accords protection to thousands of plant and animal species, by regulating their international trade, with the level of protection afforded dependent on each species' biological status. Obviously, knowledge of the true extent of harvest and international trade in moss is critical to determine whether any moss species should be listed under CITES. The work reported here was intended, in part, to inform the CITES Animals and Plants Committees, which are responsible for developing and maintaining standardized lists of species that are exploited for international trade, about exports of moss (and liverwort) species.

It is hoped that results from this study will enhance the ability of the US Fish and Wildlife Service and other land managers to promote sustainable harvest practices for mosses.

Sustainability considerations should include both economic and ecological perspectives. While it is widely accepted that bryophytes have important functions in forest ecosystems, we lack information on whether or not commercial harvest affects these functions. Acknowledged, but not necessarily quantified, roles for bryophytes in forests were recently reviewed by Studlar 2003) and include: capture, retention, and gradual release of water and nutrients; buffering of microclimatic conditions, particularly of moisture and thermal regimes; provision of habitat for invertebrates and vertebrates; provision of food and nesting material for birds and small mammals; and influences on the seed beds found on coarse woody debris and the canopy branches of trees. In addition, bryophytes stabilize soils and contribute substantially to the species diversity of forests. To address important questions about the influence of commercial harvesting on any of these "ecosystem services," large-scale studies are needed. Such studies are, however, beyond the scope of the work reported here.

Overall objectives for the work reported here were to:

- Summarize available information on quantities of moss being harvested from Federal and non-federal forested lands within the PNW and Appalachian regions of the U.S.,
- Determine the relative importance of export *versus* domestic trade in harvested moss, and
- Determine which species comprise the bulk of the harvested/sold/exported material in both regions.

These objectives were met to varying degrees, depending on availability of data. The work brings together information on commercial moss trade that has not previously been summarized on such a large scale. Results allowed us to develop recommendations for: future research, methods to improve data availability, and thus facilitate similar information-gathering efforts in the future; and management of the forest moss resource..

Methods

Geography of Coverage:

This work focused on moss harvest from the Pacific Northwestern and Appalachian regions of the U.S. Coverage in the PNW included southeastern AK, northwestern CA, and western OR and WA. Coverage in the Appalachians included AL, GA, KY, NC, NY, OH, PA, SC, TN, VA, and WV.

Data Collection

Surveys and other sources of information on harvest and sale quantities:

We used surveys to gather much of the information reported here. Surveys were sent to three primary interest groups: land managers who oversee forested lands in the two regions of study, botanists and bryologists working in both regions, and commercial moss dealers (suppliers, wholesalers, and retailers). Copies of the survey forms and accompanying cover letters are in Appendix 1. Some of the questions included in surveys were in common between one or more groups (e.g., "Do you think present levels of regulation for moss harvesting are adequate, inadequate, excessive, or no opinion?"). Other questions were relevant to only one or two of the groups (e.g., for land managers this included questions about whether or not they issue permits for moss harvest and numbers of permits granted per year; for bryologists, questions about the species included in harvest and whether any are species of concern; and for businesses, questions about source of material, types of products and quantities sold, and place of sale). Survey forms were numbered, to protect anonymity of respondents, and, it was hoped, to increase response rates. We included self-addressed, stamped envelopes in paper mailings, again to encourage responses.

We mailed surveys over the course of several months, and recorded responses in a database. In general, we did not make a second attempt to communicate with non-respondents, although we did in a few cases where it seemed that the contact might have particularly useful information. Several respondents suggested additional contacts, and we attempted to send surveys to all of these as well. Some of the latter were contacted by U.S. mail, while others were contacted electronically. Some respondents indicated an interest in further discussion of moss harvesting issues, and we made follow-up telephone calls to these individuals. I also met in person with two large-scale moss dealers, one in each region, and with the Forest Botanical Product Specialist for the National Forests in North Carolina.

We also obtained yearly moss harvest permit records maintained by the BLM for OR and WA (USDI BLM 1989, 1991, 1993, 1995, 1996, 1997, 2001; http://www.or.blm.gov). These records provide information on numbers of moss harvest permits granted (for most yrs), amounts of moss harvest covered by these permits, and the dollar value of the permits associated with that harvest. Data on the value of moss harvest permits sold in the U.S. National Forest system per fiscal year were available for the U.S. overall (www.fs.fed.us/forestmanagement/reports/sfp/index.shtml), derived from the Automated Timber Sale Accounting System (ATSA). This data base gives national and Region-level information on the number and value of moss harvest permits and permitted harvest quantities per yr, beginning in 1996 (prior to 1996, moss was not identified as a unique product; B.J. Anderson, Financial Specialist, WO Financial Management Systems Staff, Functional Team, USFS, pers. comm. 2004). We obtained national- and regional-level data from this database (provided by B.J. Anderson, cited above).

Species composition:

In addition to asking participants about which species they know or believe to be included in harvests, we obtained samples of material from several sources (Appendix 3). Samples of material confiscated from illegal harvests were furnished by two land managers (from the Sweet

Home Ranger District, Willamette National Forest, OR and the Skokomish River Drainage, WA) and another sample was furnished by an individual with the Division of Natural Heritage in VA, who collected it near a site where "significant quantities" of moss had apparently been stolen days before the sample was collected. We also obtained, from participants, lists of species identified in previously confiscated harvests. We purchased moss from craft and garden stores in both regions, and also purchased moss directly from dealers, usually ordering it from their web sites. Most purchased samples had volumes between ~ 2 and 16 l, although some were larger and some smaller (Appendix 3). Three samples (samples 47 – 49) were particularly large and species determinations were made for random subsamples from these purchases. Species determinations were made for the entire purchased sample in all other cases. Purchases were opportunistic, and depended on which moss dealers responded to our request to purchase and where we (or colleagues) were able to visit stores to make direct purchases. Thus the sample was neither systematic nor truly random, and it may not represent the full range of moss products being sold from the two regions. Finally, we obtained information on harvested species from papers published in the scientific literature or from as yet unpublished work by others.

Moss samples (packaged as purchased, where relevant) were mailed to two bryologists, one specializing in the moss flora of each region (PNW -- J.L. Peck, U MN and Appalachians -- D.K. Smith, U TV). They identified all species included in each sample, using dissection and compound optics to examine microscopic characters critical for accurate species determinations. Abundance codes were assigned to each species, and data were recorded on the frequency of occurrence of each species (the percentage of samples in which it occurred). Abundance codes, along with previously published information on species composition of harvested material, allowed distinction between "target" species (those that had relatively high frequency and abundance and appeared to be harvested intentionally; Peck 1997a) and "incidental" species (those that were inadvertently included in harvest, usually by virtue of being small and growing intermixed with target species). The relative abundance of each species from PNW material was scored in classes corresponding to its percent volume in the sample (trace, 1 – 10%, 11 – 49%, and $\geq$ 50%). Abundance in the Appalachian material was scored similarly as dominant (> 50% of biomass), codominant (> 50% of shared dominance), minor element ($\leq$ 25% of biomass), or trace (one or several shoots; < 5% of biomass). Voucher specimens for PNW material are stored in the Muir laboratory at Oregon State University.

Species lists were compared to lists of species that are of concern in both regions (e.g., formerly listed as "survey and manage" species under the Northwest Forest Plan [USDA and USDI 1994, USDA and USDI 2001], or intended for some degree of special consideration under proposed revisions for the Survey and Manage Mitigation Measure Standards and Guidelines [USDA and USDI 2003] or on state sensitive species lists) and this comparison, along with opinions of bryologists and botanists in both regions was used to evaluate whether species of concern are included in commercial harvests. Nomenclature for Appalachian material is referenced to names and authorities reported by Crum and Anderson (1981) and Anderson et al. (1990). Primary literature consulted on the taxonomy of bryophytes identified from the Appalachian region included Hicks 1992 and Schuster 1966, 1969, 1974, 1980, 1992a, 1992b. Nomenclature for PNW material followed Anderson et al. (1990) for mosses, Stotler and Crandall-Stotler (1977) for hepatics (liverworts), and Esslinger and Egan (1995) for lichens.

Export data:

Data on exports of moss from the US were obtained from the U.S Department of Commerce Census Bureau's Trade Data Services, which maintain Harmonized Tariff Schedule (HTS) records for exports of various products. These data report the US dollar value for exports of "mosses and lichens suitable for bouquets or for ornamental purposes, fresh, dried, dyed, bleached, impregnated or otherwise prepared" (HTS code 0604.10.0000). Data provided under this HTS code are compiled from trade and tariff data from the U.S. Department of Commerce, U.S. Treasury, and U.S. International Trade Commission. Dollar values for total exports per year are provided (http://dataweb.usitc.gov/), and are available broken down more finely from Trade Data Services by U.S. Customs district of departure and country of destination. We used data for domestic exports only, ignoring exports that originated in countries other than the U.S. (Note that other export codes include mosses, however these codes are much broader in terms of the commodities that they include, hence are less useful. These include the Standard International Trade Classification [SITC] code 29272, "foliage and other parts of plants [without flowers or flower buds], grasses, mosses, etc. for bouquets or ornamental use, fresh, dried, dyed, etc." and the North American Industry Classification System [NAICS] code 113210, "forestry products.") We attempted to acquire export data for moss alone from several TRAFFIC offices in the US and internationally, but they either did not have this information or were not responsive to our requests. (TRAFFIC is a wildlife trade-monitoring network that is a joint program of the World Wildlife Fund and IUCN-The World Conservation Network [http://www.traffic.org]. It works in close cooperation with the Secretariat of the Convention on International Trade in Endangered Species of Wild Fauna and Flora [CITES].) Contacts in the U.S. Department of Commerce's Bureau of Economic Analysis were unable to provide export information other than that available in the Harmonized Tariff Schedule code database. Port Import Export Reporting Service (PIERS; http://www.piers.com), an organization equipped to search for monthly export records by product, exporting company, quantity, and destination in considerable detail, may have been able to provide records for some specific types of moss products, but the charges were more than our budget allowed. Finally, we consulted with several NTFP specialists, agriculture or forestry economists, and commercial moss dealers, seeking additional insights into moss export quantities.

Data Analysis and Summary

For the most part, data analysis and summary consisted simply of tabulating responses from survey participants and the bryologists who did the species identifications. However, some information gaps made it necessary for us to calculate estimated quantities, as follows.

Permitted harvest quantities:

We asked land managers for information on the quantities of moss that they issued harvest permits for yearly for the past 5 yrs, and asked that they furnish information on an air dry weight basis, if possible. (Air dried commercial moss ranges between 0 – 15% moisture content by weight; pers. comm. from various moss dealers.) However, many land managers do not maintain records on a dry weight basis, hence we converted information provided in other forms to an

estimated dry weight basis. This estimation was necessary for 8 of the 29 land managers who provided permit data on a weight basis; some provided information on a land area or time basis. The basis for our conversions is given in Table 1. We then summed harvest quantities associated with the available moss harvest permit records (described above); when necessary, correcting to an air dried weight basis. For data available from other sources for the BLM and USFS (USDI BLM 1997, 2001; J Gordon, OR BLM, pers. comm. for BLM 2002 and 2003 data; B.J. Anderson, Financial Specialist, WO Financial Management Systems Staff, Functional Team, USFS) we adjusted moss quantity data, provided in pounds to kg and then to air dried kg using the 0.55 or 0.72 correction factors (Appalachians and PNW, respectively; Table 1) as appropriate.

Table 1. Units provided by land managers for permitted moss harvest quantities or by businesses for sales quantities and conversion factors used to estimate air dried weight for these data.

Permitted units provided by manager	Factor used to convert to air dried mass	Reference[1]
Air dried weight	No conversion necessary	
Fresh (or "wet") weight – Appalachians	Fresh weight * 0.55[2]	T. Thomas and G. Kauffman, pers. comm.
Fresh (or "wet") weight – PNW	Fresh weight * 0.72[3]	J. Peck and N. Vance, pers. comm.
Bushels	1.6 kg per bushel	N. Vance, pers. comm.
Bales	11.4 kg per bale	J. Peck and T. Thomas, pers. comm.
Cubic feet	1.8 kg per cu. ft.	http://www.hiawathacorp.com/mossmeasure.htm
Tractor trailer ("semi") truck	7,701	T. Thomas, pers. comm.
"100 lb. feed sacks"	6.1 kg per sack	T. Thomas, pers. comm

[1] T. Thomas is a moss dealer in Rainelle, WV (Appalachian Root and Herb). G. Kauffman is Forest Botanical Product Specialist with the National Forests in NC, Asheville, NC; J. Peck is a bryologist who has published extensively on moss harvest issues and is currently affiliated with the Department of Forest Resources at the University of MN, St. Paul campus; and N. Vance is a Research Plant Physiologist with the USDA Forest Service's PNW Research Station in Corvallis, OR, and worked for several years in the non-timber forest products program.
[2] 0.55 = (1 – mean moisture content of fresh moss) where mean moisture content is 0.45 (45% by weight) for Appalachian moss, averaged over the seasons (information provided by T. Thomas, Appalachian Root and Herb, which buys large quantities of moss each year).
[3] 0.72 = (1 – mean moisture content of fresh moss) where mean moisture content is 0.28 (28%), derived as the frequency-weighted average from fresh samples collected across several yrs from the Hebo District of the Siuslaw National Forest, OR (J. Peck, pers. comm.).

Export quantities

Three problems posed by the export data required solutions. First, export data are provided in U.S. dollars, rather than in units of mass or volume. The variability in moisture content of moss exports, and other floral green products, necessitates this standardization to dollars, as information on export weight or volume would not be standardized and hence would be difficult to interpret (Alexander et al. 2002). However, because we wanted to estimate quantities of moss being exported, we converted the export data from dollars to air dried mass. To convert, we used two price figures, and divided dollars of exports by these dollars per kg figures to derive estimated kg of export. The figures are reasonable upper and lower bounds for prices per air dried kg, and were obtained through consultation with large-scale moss dealers and by calculating a mean price from price lists available on the internet. These figures are U.S. $4.40 per kg air dried weight ($2.00 per lb) and U.S. $6.60 per kg air dried weight ($3.00 per pound). We excluded the most expensive forms of moss products, usually small packages of "mood moss" (commonly *Dicranum* spp.) from the calculated average, as they represent a small proportion of moss products listed for sale, and likely represent a small proportion of exports, most of which are likely to be bulk quantities. This exclusion, however, means that our estimates of exported quantities derived from dollar values might be generous compared to actual

quantities (i.e., our estimated quantities may be higher than the actual export quantities). On the other hand, our estimated quantity could be conservative, if export prices are commonly lower than the range that we used. This seems unlikely, as the dealers who reported values in this range are large-scale dealers and likely to charge less per unit weight than smaller dealers might.

The second problem with export data is that they cover exports from the U.S. overall, while our focus was on moss harvest from the PNW and Appalachian regions. These regions are recognized, however, as supplying the vast majority of the moss harvested for decorative purposes (as opposed to "peat moss") in the U.S. (see Schlosser et al. 1992; von Hagen et al. 1996; Vance and Thomas 1997; Alexander et al. 2002). Because of the overwhelming dominance of these two regions as moss sources, we did not consider the national scope of the export data as a significant problem for our purposes.

The third problem posed by the export data was more challenging to address, and concerns the fact that the value of exports is given for a combined category that includes moss, lichens, and, club mosses (*Lycopodium spp.*). We attempted to estimate the fraction of the total derived from sales of moss alone, by perusing product lists available on the internet and elsewhere and estimating the proportion of items for sale that are mosses *versus* lichens. This approach led to our using a range of percentages to derive estimated moss sales values. At the upper end, we estimated that moss comprised 80% of sales dollars, and at the lower end, that moss comprised 60% of sales dollars.

These approximations resulted in four estimates of moss export quantities per year for the past 5 yrs in air dried kg:

(1) ($ in exports * 0.8) / $4.4 per kg = kg air dried moss
(2) ($ in exports * 0.6) / $4.4 per kg = kg air dried moss
(3) ($ in exports * 0.8) / $6.6 per kg = kg air dried moss
(4) ($ in exports * 0.6) / $6.6 per kg = kg air dried moss

Actual harvest and domestic sales quantities

The records of permitted harvest that we obtained do not provide a complete picture of moss harvest quantities (in fact, probably represent only a fraction of the actual harvest) for the following reasons. First, a significant fraction of land managers in areas where moss harvest permits are likely to be granted did not reply to surveys (see Results), so we have no information on quantities of harvest that they may permit. Second, several sources, from both the land manager and moss dealer groups indicated that some harvesters obtain a permit for the minimum amount of harvest allowed under one permit, but then go on to harvest more than the permitted quantity. Thus, permit records do not necessarily match the quantities of moss that are actually removed under permits. Third, some land managers responded that they do allow moss harvest, but that quantities of harvest are unrestricted, or are restricted only in units of time or area. This approach to permitting seemed to be more common on privately owned lands (e.g. timber or mining company lands) than on public lands, as indicated both by survey responses and by conversations with moss dealers. Hence we have no way to estimate quantities of legal harvest that are not associated with permits. Finally, illegal harvesting is believed to be widespread and

is commonly assumed to involve at least as much moss as does legal harvest, and potentially many times more than that (see Results).

We estimated total harvest quantities based on the following assumptions: (1) Quantities of moss being exported are reasonably bracketed by the methods described above, and (2) Exports represent at most 10 and 20% of total moss sales. These percentages were derived from survey responses (moss dealers were asked about the fraction of sales that is domestic *versus* exported) and from conversation with two large-scale moss dealers. To derive estimates of total harvest, we divided estimated moss exports by 10% or 20%, corresponding to the percentage of sales that is by export. Thus, we provide eight estimates of total harvest quantities (each quantity represented by Eqns. 1 – 4 above divided by 0.1 and by 0.2). We then compared these quantities to reported permitted sales quantities to determine what fraction of the total harvest seems to be encompassed by the reported permitted sales. Note that the 10 – 20% export range may be higher than the rate that applies across the industry, as many businesses indicated that they do not export moss at all; estimates of total and domestic quantities based on this approximation are, therefore, likely to be conservative compared to actual quantities.

Domestic sales quantities were estimated simply by subtracting each estimated export quantity from each estimated total harvest quantity. This estimation method assumes that trends over time in export sales are mirrored by trends in domestic sales; this assumption is untested. Factors that affect export markets may not be the same as factors influencing domestic markets, and if these are uncoupled, then estimates of total and domestic sales based on exports would be erroneous.

Results

Survey Response Rates and Geography of Responses

Response rates were uneven across the surveyed groups (Table 2; names and addresses for surveyed individuals and groups are in Appendix 2; surveys are in Appendix 1). The highest response rate was for bryologists and botanists; 51% of the 88 individuals surveyed responded. These scientists were, for the most part, based in and most familiar with mosses in states of interest to this study, with 15 of the 45 respondents representing states in the PNW and 28 affiliated with the Appalachian region. Others came from states outside of the study area or did not indicate a particular geographical expertise.

Lowest response rates were for commercial moss dealers; only 21% of the 105 businesses to whom we sent surveys responded (Table 2). Businesses that responded were located in CA, FL, KS, OR, TX, WA AND WV (one dealer from GA sent samples but did not respond to the survey). It is important to recognize that many businesses buy products from and sell them to a wide area, such that their home bases do not necessarily reflect the areas from which they purchase moss, nor to which they sell moss. For example, one of the larger moss dealers in the U.S., Hiawatha, Inc. has headquarters in WA but sells much of its moss in the eastern U.S., and supplies moss to a wholesaler in TX (M. Thompson, Hiawatha, Inc., pers. comm.). Low

Table 2. Surveyed populations and response rates for surveys about commercial moss harvesting, broken down by interest group.

Interest Group	State(s) from which Responses were Received	No. of Surveys Sent	No. of Responses Received	Response Rate (%)
Land Managers				
U.S. Forest Service	AK, AL, CA, GA, KY, NC, OH, OR, PA, SC, TN, VA, WA, WV	148	68	46
Bureau of Land Mgmt.	AK, CA, OR, WA	28	18	64
Nat. Park Service	WA	3	1	33
Tribal (B.I.A.)	AK, CA, NC, OR, WA	52	19	37
State Forest	AK, CA, GA, KY, NC, NY, OH, OR, PA, TN, VA, WV	82	44	54
Timber Company	CA, ME, OR, WA	48	25	52
Others[1]	NY, TN, WA	11	5	45
Total for Land Managers	AK, AL, CA, GA, KY, ME, NC, NY, OH, OR, PA, SC, TN, VA, WA, WV	372	179	48
Bryologists/Botanists	AK, AL, CA, DC, GA, ID, IN, KY, MI, NC, NY, OH, OK, OR, PA, SC, TN, VA, WA, WV (and BC, Canada)	88	45	51
Businesses	CA, FL, KS, OR, TX, WA, WV	105	22	21
Grand Total-(Totals include 20 surveys sent to Foundations , private organizations concerned with forest resource issues, trade groups, and agencies that deal with export/import issues.)[2]	AK, AL, CA, DC, FL, GA, ID, IN, KS, KY, ME, MI, NC, NY, OH, OR, PA, SC, TN, TX, VA, WA, WV-(and BC, Canada; Cambridge, UK)	584	251	43

[1] "Others" included Big South Fork National River and Recreation Area, TN; WA Dept. of Natural Resources (Central, Southwest, South Puget Sound, Olympic, and Northwest Regions and the Olympia Headquarter); and NY State Bureau of Public Lands (Lands and Forests Region 3, Wappingers Falls Sub-office, Lands and Forests Region 4, and Stamford Sub-office)

[2] Oregon Association of Nurserymen, Wholesale Florist and Florist Supplier Association, The Society of American Florists, Pacific West Community Forestry Center, National Network of Forest Practitioners, Alliance for Sustainable Jobs and the Environment, Alliance of Forest Workers and Harvesters, National Forest Foundation, Economic Development Council of Mason County, Robert McLure (writer), Bureau of Economic Analysis U.S. Department of Commerce, U.S. Census Bureau, TRAFFIC (Regional Offices for East Asia, Southeast Asia, Europe, North America, and TRAFFIC International)

response rates for commercial moss dealers were influenced by delivery failures; 16 of the 105 surveys sent to businesses were returned as undeliverable by the US Postal Service (~ 15%). If delivery failures are excluded when calculating response rates, then response rate was close to 25%, still lower than rates for other interest groups.

Forty eight percent of the 372 land managers to whom surveys were sent responded (Table 2). We had anticipated a higher response rate for this category, since approximately 84% of land manager survey recipients were governmental (federal, state, or tribal) employees. Thirty eight percent of land manager respondents (40% of recipients) were affiliated with the USFS. Recipients within the USFS represented 31 National Forests (14 in the PNW and 17 in the Appalachian region) and 69 Districts within those forests had respondents; 64% of USFS respondents were from the PNW and 36% of respondents came from forests in the Appalachians. Lands managed by the BLM were represented by 10% of land manager responses (7% of recipients), coming from 4 states in the PNW (most from OR), and 18 unique districts or offices within those states. Tribal responses constituted 11% of land manager responses received (14% of recipients), and these came from AK, CA, NC, OR, and WA. State Forests were represented by 24% of land manager responses (22% of recipients) and came from 44 State Forest Offices across 3 states in the PNW (AK, CA, and OR; we also received responses from the WA Dept. of Natural Resources) and 9 states in the Appalachian region. Private timber companies provided 14% of land manager responses (13% of recipients), and came from companies headquartered in or with major holdings in three and one PNW and Appalachian states, respectively.

Moss Harvest Permit Records

While 179 land managers (48% of recipients) responded to surveys, many of these did not answer all questions and, in some cases, answers provided by a given manager about permitting practices were inconsistent from question to question. Hence, numbers of respondents are rarely the same from question to question.

Ninety-seven (54%) of the 179 land manager respondents across all categories of managers (e.g., federal, state, etc.) and both regions indicated that permits are required for commercial moss harvest from their lands (Table 3; percentages calculated using data in Table 2; see Appendix 1 for survey forms). This 54% excludes managers who said that permits would be required if they received requests to harvest, but that they had not received such requests. Another 14.5% of the 179 respondents allow commercial harvest without permits. No managers indicated that they had denied requests for harvest received within the past 5 yrs. (We know, however, that some do deny requests, including the Monongahela National Forest in WV, which imposed a moratorium on commercial moss harvesting in November of 2001 [Studlar 2003].)

Despite the relatively large number of manager respondents who said that they do require permits for commercial moss harvesting, the numbers who reported having actually issued permits in the last 5 yrs were smaller (Table 3). When asked whether they had received requests for permission to harvest moss for commercial purposes within the last 5 yrs, 35% (57 managers) of the 164 land managers who replied to this question indicated that they had received such requests, while another 52% said that they had not received such requests, and the remainder

Table 3. Responses from land managers about permitting of commercial moss harvesting. The first three data columns are numbers of respondents, and reflect their status as of the year 2002 or 2003. Ranges for allowable harvest per permit and prices per permit are across the 6 yrs for which data were provided. Data on moss quantities were converted to air dried kg (when necessary) using factors provided in Table 1. Responses from National Park managers in both regions were omitted, as none reported permitting moss harvest. No timber company managers from the Appalachians responded to surveys. "Unlim." indicates unlimited quantities allowed per permit; "per section" refers to land sections (640 ac [259 ha]).

Region and Land Management Type	Require Permits	Have Received Permit Requests in Past 5 Yrs	Allow Harvest Without Permits	No. Permits Granted Per Yr						Quantity of Harvest Permitted per Yr (air dried kg)						Allowed Harvest per Permit (air dried kg; max., min.)	Price per Permit (U.S. $; max., min.)
				97	98	99	00	01	02	97	98	99	00	01	02[1]		
Appalachians																	
U.S.F.S.	15	11	1	1	8	29	18	10	0	7	1993	4074	4360	2604	0	7 – unlim.	$0.60/kg to $2.21/kg
Tribal	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
State	9	5	2	2	3	0	0	0	0	3	5	0	0	0	0	-	-
Total for Appalachians	24	17	3	3	11	29	18	10	0	10	1998	4074	4360	2604	0	7 – unlim.	$0.60/kg to $2.21/kg
PNW																	
U.S.F.S.	26	19	6	121	121	133	239	165	143	37508	37508	38617	39530	41096	41191	17 – unlim.	Free to $0.15/kg, $45.00 flat rate
BLM	12	7	7	85	30	112	114	104	98	18583	4227	38246	37187	50748	30849	453 - 861 (per section); unlim.	$0.09/kg to $0.12/kg
Tribal	11	3	4	0	0	0	0	0	1	0	0	0	0	0	45	Tribal members only	Free
State	10	4	5	34	40	19	33	24	19	8562	10193	4485	12149	24788	15656	566 - 1305	$0.15/kg to $50.00 flat rate

Table 3, contd.																
Timber Co.	14	7	1	12	6	5	6	5	6	0	6704	7157	73567	0	0	Unlim.	Variable units
Total for PNW	73	40	23	252	197	269	392	298	267	64653	58632	88505	162433	116632	87741	17 – unlim.	Free to $0.15/kg, $50.00 flat rate
Overall Total	97	57	26	255	208	298	410	308	267	64663	60630	92579	166793	119236	87740	7 – unlim.	Free to $2.21/kg, $50.00 flat rate

[1] Appalachian land manager respondents reported no permits and no harvest for 2002, however this reflects data availability at the time our surveys were received rather than an actual lack of commercial moss permitting during that year (see Table 4).

marked "not applicable." Proportions were similar between the Appalachians and the PNW: 55 and 51% of respondents from the Appalachians and PNW, respectively, indicated that they had not received such requests, while 30 and 37%, respectively indicated that they had received requests to harvest commercial quantities of moss. Respondents from the USFS in the two regions reflected similar patterns with regard to requests for permission to harvest for commercial use; in each case, approximately half of respondents had received requests and half had not (N = 19 and 18, respectively for the PNW; 11 and 12 for the Appalachians). Patterns differed between regions for state forest lands; in the Appalachians, almost four times as many managers had not received requests as had received requests (19 *versus* 5 managers), while in the PNW, approximately twice as many state forest managers had not received requests as had received such requests (N = 7 *versus* 4 managers).

Most land manager respondents who grant permits for commercial moss harvesting also charge for those permits. The only exceptions in the PNW were one manager with the USFS (out of 16 PNW USFS managers who answered "yes" or "no" [rather than "not applicable"] to this question) and five Tribal managers who grant permits but do not charge for them (N = 11 Tribal managers answering "yes" or "no" to this question; most Tribal managers grant permits only to Tribal members.). In the Appalachians, only two respondents out of the 26 who answered "yes" or "no" to this question grant permits with no charge; both were associated with state forests (six Appalachian state forest managers reported that they do charge for permits).

Numbers of permits that respondents reported granting per year varied widely across the years included in surveys (1997 – 2002), ranging from totals of 410 permits in 2000 to 208 in 1998 (Table 3). Managers in the PNW than reported more permits than did those in the Appalachians, partly because the BLM is a major contributor to permitting in the PNW but does not manage forested lands in the Appalachian region. However, the difference between regions goes beyond this, in that US Forest Service managers from the PNW reported issuing far more permits than such managers from the Appalachians (Table 3). The difference in permit numbers issued by the U.S. Forest Service in the two regions is influenced by differences between regions in numbers of managers who reported granting permits (17 *versus* 40 for the Appalachian and PNW regions, respectively); however differences in permit numbers are much greater than the difference in numbers granting permits.

Allowable harvest quantities per permit varied widely in both regions, with "unlimited" harvest being the upper end and 7 kg (air dried weight) being the minimum. (Table 3; see Table 1 for factors used to convert data provided in various units to air-dry weights.) Fifty-three percent of the 90 managers who indicated that they allow commercial moss harvesting, require permits for this harvest, and who responded to the question of whether or not they maintain records on quantities of moss harvest covered by permits do maintain such records. Approximately 47% of these respondents do not maintain permitted harvest quantity records. The percentage of managers who reported maintaining records on permitted quantities was higher for the PNW than for the Appalachians (58 *versus* 43%). In the PNW, more managers of state forest lands reported that they do not maintain such records than reported keeping such records (the ratio of "no" to "yes" was 6 to 3) while numbers of state forest managers that do and do not keep records were equal for the Appalachians (4 for both cases). By contrast, more USFS managers reported that they do keep permitted harvest quantity records than not (ratios of "yes" to "no" were 15 to

2 and 9 to 5 for the PNW and Appalachians, respectively). Seven private timber company land managers in the PNW responded that they do not maintain permitted harvest quantity records, while five reported that they do maintain records.

Managers that maintain harvest quantity records reported permitting harvest of between 60,630 and 166,793 kg per yr (air dried) of moss during the years 1997 through 2002 (Table 3). (Note that actual harvest quantities may differ from permitted harvest quantities. Permit records are, by and large, based on the maximum allowable harvest under one permit, and some harvesters may take less or more than that quantity. Agencies that grant permits do not, generally, require harvesters to report on quantities actually taken. For simplicity, however, the terms "permitted harvest" and "harvest quantities" are used throughout this report.) The mean reported permitted harvest per yr across the years 1997 – 2002 was 98,607 kg across both regions; 96,433 kg for the PNW and only 4,009 kg for the Appalachians (excluding the years 1997 and 2002 for the Appalachians, when permitted harvest probably occurred but none [or almost none] was reported by respondents). Reported harvests were highly variable year-to-year, with no consistent upward or downward trend being suggested by the data. Total permitted harvests reported by respondents were much greater for the PNW than for the Appalachian region (Table 3). Maximum reported permitted harvest from the Appalachians was in the year 2000, when 4,360 kg (air dried) was reported, while the maximum from the PNW was 162,433 kg (air dried), also in the year 2000. The bulk of permitted harvest reported by respondents from the Appalachians came from USFS lands (no other land management groups from the Appalachians reported any harvest from the year 1999 on), while in the PNW, most of the reported harvest was fairly evenly divided between lands administered by the USFS and the BLM, with lesser quantities from state lands and timber company lands (the latter provided information only through the year 2000).

In 2002, prices per permit varied widely (Table 3). Reported prices ranged from free (no charge) to about U.S. $2.21 per kg (air dried), but also included "flat fees" (e.g. U.S. $50 for a permit) without specifying associated quantities of moss. Some respondents (particularly those from timber companies) provided data on prices that were based on units other than moss quantities, such as prices per month or per unit land area, and these could not be converted to a price per unit moss basis.

Data from other sources indicate that the US Forest Service took in revenues of between U.S. $7,573 and $14,591 per yr from moss harvest permit sales during fiscal years 1997 – 2003, respectively (Table 4; B.J. Anderson, Financial Specialist, WO Financial Management Systems Staff, Functional Team, USFS and www.fs.fed.us/forestmanagement/reports/sfp/index.shtml (accessed March 2004)). This income was accrued to the entire National Forest System; broken down by USFS Region, it is apparent that much more revenue for moss harvesting was collected in the PNW than in the Appalachians, particularly in 1997, 1998, 2002, and 2003 (Table 4). The BLM in OR and WA reported moss harvest permit revenues of between U.S. $2,859 and $10,774 per yr during fiscal years 1997 – 2003 (Table 4; USDI BLM 1997, 2001; J. Gordon, District Forester, OR BLM, pers. comm. for 2002 and 2003 data). Land managers who responded to our surveys reported moss harvest permit revenues of between U.S. $8,741 and $20,175 per yr between 1998 and 2001, with the bulk of these revenues being reported by managers from the PNW (Table 4). Greater revenues from the PNW result partly from BLM and timber company lands' contributions to revenues, but reported revenues for USFS and State lands were also much

greater for the PNW than for the Appalachians. For example, revenues for 1998 – 2001 reported by USFS manager respondents from the PNW totaled U.S. $29,610, while USFS managers from the Appalachians reported only $1,986 over those years. Regional differences in permit costs for USFS lands also contribute to this difference between regions; prices per permit were higher, in general, in the PNW than in the Appalachians (Table 4; average price per permit from PNW = $140.74 and for Appalachians = $23.30, based on data from the USFS WO Financial Management Systems Staff; average prices calculated by dividing permit revenues per yr by numbers of permits granted per yr). In 1999 – 2001 (the years for which our respondents provided the most data on permit revenues), revenues reported by our respondents were higher than those published by the BLM and USFS (*op.cit.*; Table 4). This difference might be expected, given that revenues reported by our respondents included those from state and timber company lands, but it also suggests that we may have had reasonably complete reports for those years.

Permit numbers corresponding to revenues provided by the BLM (Table 4) ranged between 62 and 229 permits per yr between 1998 and 2003. (If 2003 data are excluded, since they may have been incomplete at the time they were published, the minimum was 90 permits per yr.) These published permit numbers are similar to those reported by our BLM respondents for some years (e.g., see data for 1999-2001 in Table 3), however data provided by our BLM respondents were incomplete for 1997, 1998, and 2002. By contrast, our USFS respondents from the PNW reported more permits than were recorded in the USFS database system (compare Tables 3 and 4). However, for the Appalachians, permit numbers reported by our respondents were far fewer than the permit numbers recorded in the USFS database system. This inconsistency may result, in part, from the USFS database system covering more states in USFS Regions 8 and 9 than were included in our surveys, however this does not account fully for the discrepancy. For example, the Forest Botanical Product Specialist for the National Forests in NC told us that 236 permits were issued for moss harvest on these forests in 2002 (G. Kauffman, pers. comm. 2004; Table 3), a year for which USFS respondents from the Appalachians reported no permits and for which the USFS database reported 102 permits for USFS Regions 8 and 9 combined (Southern and Eastern Regions, respectively). Discrepancies between data reported by respondents and those from other sources are also attributable, in part, to the moderate survey response rates that we received.

The BLM reported issuing permits for harvest of between 38,495 and 76,358 kg of moss per yr during fiscal years 1997 – 2003 (USDI BLM 1997, 2001; J. Gordon, Salem District Forester, OR BLM pers. comm for 2002, 2003 data). After applying the 0.72 correction factor for mean moisture content of moss harvested in the PNW [Table 1], this range converts to 27,716 to 54,978 air dried kg of moss per yr (Table 4). If we again exclude data from 2003 as being partial, the minimum BLM-permitted moss harvest was 34,587 air dried kg per yr. For BLM lands in OR and WA, then, over these years, means of between 326 and 685 kg of moss were harvested per permit (based on data in Table 4). These quantities per permit are consistent with allowable quantities per permit provided by those BLM respondents that set harvest limits per permit (Table 3), which ranged between 453 and 861 kg per section of land (~260 ha). Whether these are actually the quantities harvested under BLM permits or are simply quantities reported to BLM by harvesters or buyers is unknown. A comparison of the published BLM harvested quantity data for 1997 – 2002 (Table 4) with quantity data provided by our BLM respondents for

the same years (Table 3) shows that the two are fairly similar for years other than 1997 and 1998 (years for which fewer respondents provided data than for other years). Our BLM respondents reported approximately 7,000 air dried kg more harvest than was published by BLM for fiscal year 1999, while in later years, BLM's published data were higher than ours by between 3,738 and 7,230 air dried kg per yr.

Table 4. Moss harvest permit revenues (U.S. $), permit numbers, and harvest quantities allowed by permits. Data for the National Forest System [1] are broken down by USFS Region (5 & 6 = CA and OR + WA, respectively / 8 & 9 = Southern and Eastern U.S., respectively). Data for BLM are for WA and OR[2] ;data are also summarized from survey responses for the PNW and Appalachian regions. Responses for the Appalachians were from USFS and State forest managers; for the PNW responses were from these groups and BLM, Tribal, and timber company land managers. Permitted harvest quantities from BLM and USFS sources were converted to air dried kg (see Table 1 for conversion factors). "__" indicates data not available. Permitted harvest quantity data from USFS Regions 8 and 9 during 2002 and 2003 are omitted, owing to confusion about reporting units used in the USFS database for those regions and years.

Year	Permit Revenues ($) – USFS	Permit Revenues ($) – BLM	Number of Permits – USFS	Number of Permits – BLM	Permitted Harvest – USFS (air dried kg)	Permitted Harvest – BLM (air dried kg)	Survey Responses – Permit Revenues (U.S. $) Appalachians	PNW
1997	9,956 / 246	10,774	125 / 6		63,217 / 2,029	40,514	__	__
1998	10,856 / 346	14,327	76 / 8	229	54,772 / 2,875	53,801	95	8,646
1999	6,244 / 1,329	2,859	68 / 89	94	32,643 / 24,991	31,368	1,213	11,534
2000	8,839 / 2,463	4,514	57 / 171	90	53,691 / 38,278	44,417	525	19,650
2001	12,377 / 2,214	6,511	41 / 160	125	71,534 / 44,127	54,978	167.5	17,270
2002	6,717 / 3,883	3,882	40 / 102	104	40,090 / __	34,587	__	12,962
2003	8,202 / 4,995	3,478	42 / 128	62	49,821 / __	27,716	__	__

[1] www.fs.fed.us/forestmanagement/reports/sfp/index.shtml (accessed March 2004) and B.J. Anderson, Financial Specialist, WO Financial Management Systems Staff, Functional Team, USFS

[2] USDI BLM 1997, 2001; J. Gordon, District Forester, OR BLM, pers. comm. for 2002 and 2003 data

We also obtained data on BLM permit revenues and permitted harvest quantities for years prior to 1997 (USDI BLM 1989, 1991, 1993, 1995, 1996). These data show that permitted harvests were generally much smaller than recent harvests (3,689 – 10,579 air dried kg per yr between 1988 and 1993), with correspondingly lower permit revenues (U.S. $439 – 1,305 for the same time period). In 1994, however, permitted quantities and revenues jumped abruptly to 70,779 air dried kg and U.S. $4,905. Both quantities and revenues then remained relatively high through the present time. The correlation between revenues and harvested quantities over the period 1988 – 2003 is not strong, however. For example, in 1995, permitted harvest was 67,182 air dried kg, similar to the quantity given above for 1994, however permit revenues in 1995 were over twice those from 1994 (U.S. $10,449 in 1995).

The USFS database reported that permits were issued for harvest of between 70,503 and 179,582 kg of moss per yr across Regions 5, 6, 8 and 9 during fiscal years 1997 – 2001, respectively (B.J. Anderson, Financial Specialist, WO Financial Management Systems Staff, Functional Team, USFS). (We excluded harvest quantity records from Regions 8 and 9 for the years 2002 and 2003, as it appeared that the database for those regions and years contained some records in units of U.S. tons and some in pounds, and the two could not be distinguished clearly.) After applying the 0.72 or 0.55 correction factor for mean moisture content of moss harvested in the PNW or Appalachians, respectively [Table 1], this range converts to 57,634 to 115,661 air dried kg of moss per yr (Table 4). Recall that these are quantities of moss that were paid for when permits were sold, and that they might not reflect accurately the amount of moss that was actually harvested or that was reported by buyers. For simplicity, however, quantities are referred to in this report as "harvested," or "reported," or "permitted" quantities. Reported quantities were generally much larger for the PNW (Regions 5 and 6) than for the Appalachians (Regions 8 and 9), particularly in 1997 and 1998 (when we suspect that entries into the USFS database were incomplete). Whether these are actually the quantities harvested under USFS permits or are simply quantities reported to the USFS by harvesters or buyers is unknown. A comparison of harvested quantity data contained in the USFS database for 1997 – 2001 (Table 4) with quantity data provided by our USFS respondents for the same years (Table 3) shows a pattern similar to that for the comparison of permit numbers from the two sources in the Appalachian region (described above), in that far more harvest was reported in the USFS database than was reported by our respondents. For the PNW, the match between data sources was better than for the Appalachians, with our respondents actually reporting more harvest than was recorded in the USFS database in 1999 and 2002. As for the comparison of permit numbers between data sources, the discrepancy in numbers for the Appalachians may result, in part, from the USFS database including more states than our surveys included. For USFS lands in the PNW (Regions 5 and 6) over the years 1997 – 2003 and Appalachians (Regions 8 and 9) over the years 1997 - 2001, respectively, means of ~194 and 259 kg of moss were harvested per permit (based on data in Table 4), lower than means for BLM lands.

While many harvesters operate within the bounds of the law, illegal harvesting from forests in both regions is also probably common. Thirty percent of land managers across both regions answered "yes" to the question, "If you require that moss harvesting be by permit only, are you aware of moss harvesting occurring on your lands without your permission?" (percentage calculation includes only those who answered "yes" or "no" to the question; N = 139), while 70 percent of these respondents were not aware of illegal harvest from their lands. Many of these,

however, added in comments that they have heard of illegal harvesting taking place on other lands, and conversations with a variety of individuals associated with the industry confirmed the impression that much of the harvest is probably illegal. Regional differences were apparent in responses; 41% of PNW manager respondents to this question said that they were aware of illegal harvesting occurring on their lands, while only 13% of Appalachian managers felt similarly. It was reported that illegal harvesting has been well-documented even on lands that are closely regulated and guarded, such as National Parks. For example, illegal commercial harvest of moss from Olympic National Park has been documented since about 1992, and the number of theft incidents is increasing (Hutten 1999; Hutten et al. 2001). Survey respondents reported direct knowledge of illegal harvests in Great Smokey Mountains National Park (D. Smith, U TN, pers. comm. 2004), Cedars Natural Area Preserve in VA (D. Richert, Dept. of Conservation and Recreation, VA, pers. comm. 2003), Joyce Kilmer Memorial Forest in NC (G. Kauffman, Forest Botanical Product specialist with the National Forests in NC, pers. comm.2004), and also from lands managed by a private timber company, which stopped issuing moss harvest permits owing to uncertainties about how to devise an ecologically-sound permitting process and lack of enforcement capabilities (C. Marbet, Simpson Resource Co., pers. comm 2003). Total quantities of moss being harvested illegally cannot be estimated directly.

Perceptions Concerning the Status of the Moss Resource and its Regulation

The surveys sent to each group (land managers, botanists, and businesses; see Appendix 1) asked about perceptions concerning the status of the moss resource, trends in supply and demand, and the adequacy of current regulation over harvest. Approximately 64% of bryologist and botanist respondents who answered the question, "Do you believe that the volume of moss being harvested is of concern?" replied in the affirmative while 32 percent from this group felt that volumes being removed were not of concern (N's = 14, 7, and 1 for "yes," "no," and "unknown" respectively).

Both businesses and land managers were asked a related question, which concerned their opinions about current levels of regulation for moss harvesting (Table 5). Most alnd managers with an opinion felt that current regulations are adequate. Thirty-six percent of land managers from the Appalachians who responded to this question believed that current levels of regulation were adequate, 16% believed that current regulations were inadequate, 2% felt that regulations were excessive, and 46% had no opinion on the matter. Land managers from the PNW partitioned similarly on this question with approximately 39, 13, 1, and 47% of those responding to this question believing that current levels of regulation are adequate, inadequate, excessive, or no opinion, respectively. There were no clear differences in patterns of response among land managers of various types (e.g., federal, state, etc.) in either region. None of the business respondents from the Appalachians (N = 6) felt that current levels of regulation are excessive, 33% felt that they are inadequate, 50% felt that they are adequate, and 17% had no opinion. Responses were different for businesses in the PNW, where 25% of respondents felt that current regulations are excessive, 12.5% believed that regulations are adequate while an equal percentage believed that regulations are inadequate, and the remainder (50%) had no opinion.

The regulations guiding moss harvest for land management agencies that issue harvest permits vary widely from place to place. In some cases, regulations are quite prescriptive (involving a

full sheet of explicit guidelines; e.g., USDA 1995; Willamette National Forest, OR; Eugene, OR district of BLM), while in others, regulations are so vague that essentially anything can be harvested. Some quotes from land manager responses to the survey question about their harvest

Table 5. Perceptions about the status of the moss resource and its regulation. Data are numbers of respondents; "N" after each manager type indicates number who responded to questions addressed in this table. "Ad." = adequate; "Inad." = inadequate; "Exces." = excessive; "No opin." = no opinion; "Incr." = increasing; "Decr." = decreasing.

Interest Group and Region	Present levels of harvest regulation:				Is demand for moss in your area:				
Appalachians	Ad.	Inad.	Exces.	No opin.	Incr.	Decr.	Stable	No demand for harvest.	No opin., unknown
Businesses (N = 6)	3	2	0	1	3	0	3	0	0
Land Managers (N = 56)	20	9	1	26	5	5	4	9	33
Federal	10	3	0	25	0	4	3	5	13
Tribal	0	0	1	0	0	1	0	0	0
State	10	6	0	1	5	0	1	4	20
Total for Appalachians	23	11	1	27	8	5	7	9	33
PNW									
Businesses (N = 8)	1	1	2	4	1	3	4	0	0
Land Managers (N = 109)	42	15	1	51	3	13	25	15	53
Federal	26	11	1	18	1	7	15	8	25
Tribal	4	2	0	12	1	1	4	2	10
State	7	1	0	6	1	1	3	4	5
Timber Co.	5	1	0	16	0	4	3	1	13
Total for PNW	43	16	3	55	4	16	29	15	53
Overall Total	66	27	4	82	12	21	36	24	86

regulations illustrate the variability in regulations. "No harvesting within 200 feet of live streams. Harvest only from standing trees such as Red Alder or vine maple, no harvesting of ground moss. Harvest no higher than 20 feet up in trees. No cutting of trees to get moss" (Oregon Dunes NRA, USFS). "No collection in riparian areas" (Cherokee NF, TN). "Harvest must occur where the moss would be destroyed due to tree harvest or road building. Users also must comply with protection measures for other resources" (Tongass NF, Wrangell RD, AK). "No conditions specified for moss"(Wayne NF, OH). "The only regulation is the amount of moss that can be harvested for one permit area" (a State Forest in Western OR).

When asked for opinions about trends in demand for moss, businesses in the Appalachians were evenly divided, with 50% believing that demand is increasing and 50 percent believing that it is stable; none believed that demand is decreasing (Table 5). Businesses in the PNW differed again from their Appalachian counterparts, with nearly 38% of PNW business respondents believing that demand is decreasing, 50% believing that it is stable, and only 12.5% seeing an increase in demand. (The small sample size for businesses should be kept in mind when evaluating implications of these responses.) Land manager responses to this question revealed that, for the Appalachians, similar percentages saw demand for moss as increasing, decreasing, and stable (9, 9, and 7%, respectively; Table 5). By contrast, 23% of manager respondents from the PNW thought that demand was stable, 12% thought that it was decreasing, and only 3% thought that it was increasing. Many respondents from both regions had no opinion about trends in demand (53 and 45% for the Appalachians and PNW, respectively). In addition, a considerable number of managers who responded to this question indicated that there did not seem to be any demand for moss harvest in their area. Twenty-four of the 179 land managers who responded to our question about the status of demand for moss in their areas reported that there was no demand for moss there (Table 5). Managers who reported no demand for moss harvest comprised approximately 31% of Appalachian respondents who had an opinion on the matter, while for PNW respondents, the corresponding percentage was 23%.

Businesses were also asked for their opinion about supplies of moss in their region. No business respondents from either region believed that the supply was increasing; 33 and 25% believed that it was decreasing (Appalachians and PNW, respectively); and 67 and 62.5% believed that supplies were stable (Appalachians and PNW, respectively). One PNW business (12.5% of PNW business respondents) had no opinion on the status of moss supplies.

Sales Reported by Businesses

Surveys sent to businesses that deal in moss inquired about their annual sales volume, the types of moss that they sell and corresponding prices, which states the moss that they purchase comes from, and proportions of sales that are domestic *versus* exported out of the U.S. (Appendixes 1 & 2). Because only 21% (22 out of 105) of businesses responded to surveys, results reported here are unlikely to be representative of the business as a whole. We did not inquire about prices being charged for various products, nor about total sales income, so our results do not include information on these parameters.

Table 6. Responses from businesses about types of moss products sold, source areas for moss, export sales, and annual sales per yr. "N" is number of respondents (numbers in parentheses are numbers who provided product information) For Region, "Other" included FL, KS, and TX. For columns reporting products sold or area from which purchases are made, numbers in parentheses are numbers of businesses who reported selling a given type of product or purchasing moss from a given state or region. Central Appalachian states included KY, VA and WV; Southern Appalachians included AL, GA, NC, SC and TN. Yearly sales were converted to air dried kgs using factors from Table 1. "__" indicates that no information was provided. Units associated with case sales for businesses in "Other" regions are unknown.

Region	N	Products sold	States or regions from which business purchases moss	Export sales (%'s; max., min.)	Annual sales per year (air dried kg)					
					98	99	00	01	02	03
App.	2 (1)	Mood (1) Moss Mulch (1) Sheet (1)	CentralApp (1)	0, 0, 0	__	__	__	__	__	7,475
PNW	15 (8)	Curly mood (1) Fresh assorted (1) Green (1) Mood (3) Oregon (3) Shag (2) Sheet (4) Tree (1)	CentralApp (1) SouthernApp (1) Oregon (7) Washington (5) Imported (1)	0, 0, 0	16,930	5,735	36,745	145,700	55,156	__
Other	5 (5)	Green (1) Log (1) Mood (1) Rock (1) Sheet (6)	CentralApp (3) Southern App (3) Michigan (1) Washington (1) Imported (1)	1, 5, 0	23,556 + 2600 cases	23,556 + 2600 cases	23,556 + 2600 cases	23,556 + 2600 cases	26,301 + 2600 cases	__

A variety of moss products are sold by these businesses (Table 6), and scans of web sites for additional businesses (Appendixes 2 and 5) indicated that these products, along with "decorator" moss, are the most commonly listed. The bryologists who identified species found in purchased moss samples reported on the species that comprised some of these products (see "Species included in harvests," below). Businesses commonly listed products other than bryophytes when asked to indicate what kinds of "green or dried forest mosses" they sold, commonly including Spanish moss (*Tillandsia spp)*, reindeer moss (usually the lichen genera *Cladonia* or *Cladina)*, and peat moss (sometimes, but not always, referring to *Sphagnum* species*)*. In one case, a business sent us samples of moss products that were labeled with names such as "fresh shag" and with Latin names for moss species, however the names on the labels bore no correspondence to species found in the packages. The national reach of the moss business is made clear by lack of correspondence between region of moss purchase and region of origin of species in the products (see "Species included in harvests," below) and also by the fact that some moss dealers in the PNW reported purchasing some of their moss from the Appalachian region (Table 6). Conversations with businesses that did not participate in paper surveys confirmed that it is common for companies in one region of the country to neither buy exclusively from that region nor sell exclusively (or even primarily) to that region.

Only one of the businesses who responded to paper surveys reported exporting any of their moss products out of the U.S., with this business reporting that about 5% of its sales were by export (Table 6). Conversations with other businesses, however, suggested that more export than our surveys reflected does occur, with as much as 20% of one large businesses' sales being by export. The US Commerce Division's export tracking system also indicates that substantial quantities of moss are exported (see "Moss exports," below). One business reported that it imported from outside the U.S. some of the moss that it sells.

Few businesses were willing to disclose annual sales information, either in terms of dollars or quantities of moss. The few data that were reported are given in Table 6. Maximum reported sales (in air dried kg) were for 2002, when businesses in the PNW reported selling 55,156 kg. Such reluctance to divulge sales information is apparently common among businesses that deal in NTFPs, and possible reasons for this reluctance are addressed in "Discussion," below.

Species Included in Harvests

Species were identified from 54 purchased or confiscated samples of moss products from the Appalachian (N = 20 samples) and PNW (N = 34 samples) regions (sources of all material sent out for species identifications are listed in Appendix 3). Between three and seven species of mosses and liverworts constituted the bulk of most samples, depending on the region, with material from the PNW tending to include more species, particularly more species with abundances greater than trace amounts. Most samples included more species than this, however, and these, for the most part, are probably "incidental;" or "nontarget" species; that is, collected inadvertently along with the "target" species (Peck 1996, Peck 1997a). (Henceforth we use "incidental" to refer to these species, combining Peck's nontarget and incidental categories.)

Table 7. Species found in samples of purchased or confiscated moss. **(A)** Pacific Northwest material (N = 30 samples with species determinations by J. Peck and 4 samples with species determinations by D. Smith). Data include mean abundance codes for each species across samples in which the species occurred (and standard deviations). Abundance codes are inverse: 40 = trace; 30 = species comprised 1 – 10% of the volume in the sample; 20 = species comprised 11 – 49% of the volume of the sample; and 10 = species comprised 50 – 100% of the volume in the sample. Frequency is the percent of samples in which each species occurred, based on Peck's determinations from 30 samples, except for *Hypnum circinale*, for which frequency is based on the 4 samples determined by D. Smith. Primary substrates are coded: B = tree base, E = epiphyte, including trunk and branch substrates, F = forest floor, R = rock, S/R = soil over rock, W = rotting wood. **(B)** Appalachian material (N = 20 samples with species determinations by D. Smith). Abundance data are the two most frequently occurring abundance scores for each species across all samples (in some cases, all observations fell into one abundance class and for these only that class is listed). D = dominant, C = co-dominant, M = Minor, T = Trace (see Methods for abundance class definitions). Frequency is as defined for part A. Primary substrate codes are as for part A with the addition of HS = humic soil.

A. PNW **Mosses**	Mean abundance in samples of occurrence	std	Frequency (%)	Primary Substrate [1]
Antitrichia californica	30	8	15	E, B, W
Antitrichia curtipendula	29	7	54	E, B, W
Aulacomnium androgynum	40	-	4	E, B, W, F
Claopodium crispifolium	35	5	54	B, W, F
Dendroalsia abietina	40	0	8	E, R
Dicranum fuscescens	40	0	12	E, W, F, S/R
Dicranum scoparium	31	12	38	F, S/R, W, B
Dicranum tauricum	40	-	4	W, B, S/R
Eurhynchium oreganum	30	8	58	E, W, F
Eurhynchium praelonga	38	5	15	W, F
Homalothecium fulgescens	33	7	62	E, B, W
Homalothecium nuttallii	31	3	38	E, B, W
Hylocomium splendens	33	5	15	F, W, R
Hypnum circinale	40	-	20	E, W, B
Hypnum subimponens	35	7	54	E, B, W
Isothecium myosuroides	24	8	69	E, F, R
Leucolepis acanthoneuron	36	7	35	E, B, F, W
Metaneckera menziesii	36	7	31	E
Neckera douglasii	40	0	58	E
Orthotrichum lyellii	40	-	4	E

Plagiomnium insigne	30	-	4	F
Plagiomnium venustum	35	7	8	E, B, F, W
Plagiothecium laetum	38	4	23	W, B, F, S/R
Plagiothecium undulatum	40	-	4	W, B
Rhizomnium glabrescens	37	5	23	W, F, S/R
Rhytidiadelphus loreus	20	9	50	E, W, F
Rhytidiadelphus triquetrus	34	7	42	F
Ulota megalospora	40	0	19	E
Liverworts				
Frullania tamarisci subsp. nisquallensis	36	5	38	E, W, R
Lophocolea heterophylla	40	0	8	E, B, W, F, R
Metzgeria conjugata	40	0	8	E, R
Porella cordaeana	38	4	19	E, R
Porella navicularis	28	6	77	E, W, R
Scapania bolanderi	40	0	12	B, W
Lichens				
Cladonia sp.	38	5	15	
Lobaria pulmonaria	40	0	8	
Parmelia sulcata	37	6	12	
Peltigera spp.	36	5	38	
Ramalina farinacea	40	-	4	
Usnea plicata group	40	0	19	

[1] Substrates for PNW mosses from Lawton1971 and Conard and Redfearn 1979; for PNW liverworts from Schuster 1969, 1974, 1992a and Conard and Redfearn 1979.

B. Appalachians			
	Abundance	Frequency (%)	Primary Substrate[3]
Mosses[2]			
Anomodon attenuatus	M, T	10	B, R
Aulacomnium heterostichum	C, T	10	F, R
Brachythecium aff. *plumosum*	T	5	R
Brachythecium salebrosum	M,T	45	W, F, B, R
Brotherella recurvans	M	5	W, HS, F
Bryoandersonia illecebra	T, M, C	20	F, B, R
Bryhnia novae-angliae	T	15	W, F, R
Campylium chrysophyllum	T	5	W, F, R, B
Ctenidium molluscum (=C. malacodes)	M,T	10	W, F

Dicranum aff. *fuscescens*	T	5	W, B
Dicranum montanum	M, T	10	W, B, E
Dicranum scoparium	D, M	20	W, F, R, B
Eurhynchium hians	M	5	F
Hylocomium brevirostre *(=Loeskeobryum brevirostre)*	M, T	30	W, F, R,
Hypnum curvifolium	D, C	50	W, B, F
Hypnum fertile	C, M	40	W
Hypnum imponens	D, C	15	W, B, R, F
Hypnum cupressiforme	D	5	W, F, R
Leucobryum albidum	T	5	W, F
Plagiomnium ciliare	T	30	W, F, B, R
Plagiomnium ellipticum	M, T	5	W, F, B, R
Plagiomnium cuspidatum	M, T	10	W, F, B
Rhodobryum roseum	T	10	W, B, S/R
Tetraphis pellucida	T	5	W
Thuidium delicatulum	D	80	W, R, F
Tortula ruralis	T	5	F, R
Liverworts			
Plagiochila porelloides	T	10	HS
Trichocolea tomentella	M	5	HS

[2] Single entry names are the same for Crum & Anderson (1981) and Anderson, Crum& Buck (1990), except for *Plagiomnium spp*., where nomenclature follows Anderson, Crum & Buck (1990). The use of the interfix "aff." connotes "affinity" and equates with best choice in light of poor material. In the case of the three Mnium taxa, the older nomenclature of Crum and Anderson (1981) were used. The more recent synonyms in Plagiomnium follow Anderson, Crum, & Buck (1999).

[3] Primary substrates for Appalachian material derived from D. Smith, pers. comm., based on authorities referenced in Methods, and from Studlar 2002.

Material from the PNW included 28 moss and 6 liverwort species, along with ~ 6 lichen genera (Table 7A). Eight moss and one liverwort species were found in $\geq$ 50% of samples from the PNW, but these frequently occurring species did not necessarily constitute a large percentage of the volume of the samples in which they occurred. Mean abundance scores for these species, when present, ranged between 40 (trace) and 20 (11 – 49% of sample volume), with most being having abundance scores near 30 (1 – 10% of sample volume). Considering both frequency and abundance, the most prevalent species (frequency $\geq$ 50% and mean abundance score when present $\leq$ 30) in PNW material included the mosses *Antitrichia curtipendula, Eurhynchium oreganum, Isothecium myosuroides,* and *Rhytidiadelphus loreus* and the liverwort *Porella navicularis*. Four of these species were also found in four samples of PNW origin that were purchased in the Appalachians and determined by D. Smith (*A. curtipendula* [40% frequency], *E. oreganum* [40% frequency], *I. myosuroides senso lato* [60% frequency], and *P. navicularis* [40% frequency]). The moss, *Neckera douglasii*, which was considered a target species by Peck (1996, 1997b) was frequent in the PNW material determined by both J. Peck and D. Smith (Table 7A; 60% frequency for the latter). Its abundance in most samples was, however, too low for it to be considered a prevalent species in the current study (Table 7A; abundance rank of "dominant" in two of Smith's samples, but absent in another and present as a trace in the fourth).

Samples from the Appalachian region included 28 taxa; 26 mosses and 2 liverworts (Table 7B). In contrast to findings from the PNW material, only two species occurred with frequency $\geq$ 50 percent (*Hypnum curvifolium* and *Thuidium delicatum*) and, also in contrast to PNW findings, both species did generally constitute a large percentage of the volume of Appalachian samples containing them. Considering both frequency and abundance, the most prevalent species ("dominant" abundance ranking in at least one sample or frequency $\geq$ 40%) in Appalachian samples included *Dicranum scoparium, Hypnum curvifolium, Hypnum fertile, Hypnum imponens, Hypnum cupressiforme,* and *Thuidium delicatulum*, which are mosses. The moss, *Brachythecium salebrosum* occurred frequently (45% of samples), but always in minor or trace amounts. Only one of these prevalent species, *Dicranum scoparium*, occurred in the PNW list (Table 7A), but it was not a prevalent species there. No liverworts were prevalent in Appalachian material, in contrast to findings for the PNW material.

The total species list for each region is much longer than the list of prevalent ("target") species (Table 7A, B) and the bryologists who identified species in the collections suggest that most of these incidentals are probably harvested either opportunistically (e.g., commercially desirable species that are not often harvested because they generally occur with low frequency or abundance) or because they grow enmeshed with the target species. Examples of common associates with minor or incidental element occurrences from the Appalachian material are: *Brachythecium salebrosum, Bryoandersonia illecebra, Hylocomium brevirostre,* and *Plagiomnium ciliare* (Table 7B). The remaining species are sporadic associates mixed with prevalent (target) species.

Many, but by no means all, of the moss and liverwort species identified from PNW material grow as epiphytes on trees or shrubs, particularly on hardwood species (Lawton 1971, Conard and Redfearn 1979). Approximately 20% of samples from the PNW included species that grow primarily on coarse woody debris ("logs") and approximately 11% of PNW samples included species that are commonly found of the forest floor (Table 7). .None of the five most prevalent

species from PNW material, listed above, are exclusively epiphytic; they also occur on logs, the forest floor, tree bases, or rocks. The two most common substrates for PNW species were trees or shrubs (epiphytic forms) and logs, and approximately half of the species use the forest floor itself (soil or organic matter) or tree bases as substrate. None of the PNW species use rock as their only substrate, however rock or soil over rock was listed as one of the common substrates for 13 species. Only four of these species, however, were encountered relatively frequently and abundantly in samples; *Dicranum scoparium*, *Frullania tamarisci* subsp. *nisquallensis, I. myosuroides,* and *P. navicularis* and only two of these were frequent and abundant enough to be considered prevalent (*I. myosuroides* and *P. navicularis).* Because both of these species occur fairly commonly on a variety of substrates, it is not clear whether material in the samples was collected from rock.

Most of the species identified from the Appalachian material are usually found on logs or the forest floor (soil or organic matter), and this is true for all of the prevalent species from Appalachian samples (Table 7B). One of the prevalent species, *Thuidium delicatulum*, is also found commonly on rock in addition to these substrates, and a total of 17 (~ 61%) of the species found in the Appalachian samples use rock or soil over rock as one of their primary substrates. In contrast to harvested mosses from the PNW, none of the Appalachian species are commonly epiphytic (although *Dicranum montanum* is occasionally found on tree trunks, above their bases, and several species occur fairly commonly on tree bases). *Hypnum* species and *T. delicatulum* are often sold as "sheet moss," because of the way mats can be peeled in long sheets from the logs on which they occur. The *Dicranum* species are commonly sold as "mood moss."

The bryologists who identified species in the samples indicated that none are threatened or considered particularly sensitive in their region at the present time. No moss or liverwort species are currently listed Federally with the US Fish and Wildlife Service as Threatened or Endangered (http://ecos.fws.gov/tess_public/ site accessed March 2004;). None of the species identified from PNW material are currently listed as potential Survey and Manage or special status species for forested lands within the range of the Northern Spotted Owl (USDA and USDI 2003), nor are they included in lists of rare, threatened, or endangered species compiled by the OR (http://oregonstate.edu/ornhic/tebook.pdf;accessed March 2004; document dated Feb. 2001), WA (http://www.dnr.wa.gov/nhp/refdesk/lists/plantrnk.html; accessed March 2004; document dated May 2003), or CA Natural Heritage Programs (http://www.dfg.ca.gov/whdab/pdfs/TEPlants.pdf, accessed March 2004, document dated March 2004). Alaska does not presently include any bryophytes on its state list of threatened or endangered species (Rob Lipkin , Univ. of Alaska Anchorage, Alaska Natural Heritage Program, pers. comm.) The only potential exception from the PNW material is the moss *Antitrichia curtipendula,* which was formerly listed as a Category 4 Survey and Manage Species under the Northwest Forest Plan (USDA and USDI 1994). Category 4 species were given the lowest level of protection under the Northwest Forest Plan, requiring general regional surveys to acquire information on their abundance and determine necessary levels of protection. Subsequent evaluations have removed this species from the current draft Survey and Manage lists (USDA and USDI 2003; see "Discussion"). None of the Appalachian taxa in Table 7B are species of any status concern by state or federal ranking as of April, 2004 (D. Smith, pers. comm.).

Moss Exports

Exports of moss and lichens from the U.S. in 2003 had a value of U.S. $4,214,279, and the value of these exports has apparently declined over the past 6 yrs (Table 8; see Appendix 5 for raw export data). Between U.S. $1.9 and 20.6 million per yr worth of this combined category were exported over the past 6 yrs, which, when converted to estimated dollar values for moss alone (see Methods) suggests export values ranging from U.S. $1.1 million to $16.5 million per yr.

The identity of leading moss importer nations has changed over recent years as well, with Hong Kong and Canada currently (in 2003) being the most important importers (53 and 16% of dollars, respectively). By contrast, in 1999 and 2000, The Netherlands imported 75 and 68%, respectively, of the world total imports from the U.S., while in 2003, this nation imported less than 1% of the world total imports from the U.S.

This range of estimated dollar values for moss exports alone converts to an estimated range of 766,232 to 383,116 kg (air dried) moss being exported from the U.S. in 2003 (Table 8). (See Methods for estimation technique.) Over the past 6 yrs, exported quantities were greatest in 1999, when estimated moss exports ranged between 3.7 million and 1.9 million kg (air dried), and were lowest in 2001, when estimated exports ranged between 347,005 and 173,502 kg (air dried). Unfortunately, we have no way of verifying the accuracy of these estimates, which range widely depending on assumptions about dollar values per kg and the fraction of the combined moss and lichen export quantity that is comprised of moss.

Estimates of Total Domestic Sales Quantities

Because most moss dealers would not divulge information on their annual sales, estimates of total export quantities provided the basis for estimating total domestic sales quantities, as described in Methods. Our estimate is that between 33.7 million and 694,000 kg (air dried) of moss have been sold domestically per yr over the past 6 yrs (Table 8). Estimates for 2003 range between 6.9 million and 1.5 million kg. The large range in values reflects uncertainty in assumptions about the percentage of moss sales that are domestic *versus* by export, the proportion of exports that are actually moss, and prices per kg.

Estimates of Total Harvested Quantities

The sum of estimated export and domestic sales quantities gives an estimated total moss harvest per yr from these two regions of the U.S. Total quantities are estimated to be between 37.4 million and 867,510 kg (air dried) per yr over the past 6 yrs (Table 8). Estimates for 2003 range between 7.7 million and 1.9 million air dried kg. Comparing the estimates in Table 8 with the total reported permitted harvests (Tables 3 and 4; maximum reported quantity for any year was 166,793 air dried kg) makes it clear that only a small fraction of commercial moss harvest was included in the reported legally permitted harvest.

Table 8. **A**. U. S. domestic exports of mosses and lichens (HTS code 0604.10.0000) in U.S. dollars, based on data provided by U.S. Census Bureau Trade Data Services; world totals. Estimated kg (air dried) corresponding to the moss component of these exports are based on Eqns. 1 – 4 as described in Methods. Estimates based on Eqns. 1 & 3 assume that mosses constitute 80% of the dollar value of these exports, those based on Eqns. 2 & 4 assume that mosses constitute 60% of their value. Equations 1 & 2 assume a price of U.S. $4.40 per kg (air dried); Eqns. 3 & 4 assume a price of U.S. $6.60 per kg (air dried). **B**. Estimated total sales of moss (kg air dried) based on estimated exports and assumptions that 10% or 20% of total moss sales are by export. For each yr, only maximum and minimum estimates from A. were used to estimate total sales (estimates resulting from Eqns. 1 and 4, respectively). **C**. Estimated domestic sales of moss (kg air dried), based on estimates of total and export sales. For each yr, maximum or minimum estimates from A. were subtracted from the corresponding maximum or minimum estimates (respectively) given for each set of assumptions in B..

A. Exports	U.S. Dollars (mosses & lichens)	Estimated exports (kg, air dried) of moss alone			
Year		Equation 1	Equation 2	Equation 3	Equation 4
1998	$17,323,010	3,149,638	2,362,229	2,099,759	1,574,819
1999	$20,573,185	3,740,579	2,805,434	2,493,719	1,870,289
2000	$14,615,634	2,657,388	1,993,041	1,771,592	1,328,694
2001	$1,908,528	347,005	260,254	231,337	173,502
2002	$2,021,427	367,532	275,649	245,021	183,766
2003	$4,214,279	766,232	574,674	510,822	383,116

B. Total Estimated Moss Sales	Estimates assuming that 10% of total sales are by export (kg, air dried)		Estimates assuming that 20% of total sales are by export (kg, air dried)	
Year	Maximum	Minimum	Maximum	Minimum
1998	31,496,380	15,748,190	15,748,190	7,874,095
1999	37,405,790	18,702,890	18,702,890	9,351,445
2000	26,573,880	13,286,940	13,286,940	6,643,470
2001	3,470,050	1,735,020	1,735,020	867,510
2002	3,675,320	1,837,660	1,837,660	918,830
2003	7,662,320	3,831,160	3,831,160	1,915,580

C. Estimated Domestic Moss Sales	Estimates assuming that 10% of total sales are by export (kg air dried)		Estimates assuming that 20% of total sales are by export (kg air dried)	
Year	Maximum	Minimum	Maximum	Minimum
1998	28,346,742	14,173,371	12,598,552	6,299,276
1999	33,665,211	16,832,601	14,962,311	7,481,156
2000	23,916,492	11,958,246	10,629,552	5,314,776
2001	3,123,045	1,561,518	1,388,015	694,008
2002	3,307,788	1,653,894	1,470,128	735,064
2003	6,896,088	3,448,044	3,064,928	1,532,464

Discussion

Survey Response Rates

While the percent of recipients who responded to our surveys seems small, particularly for businesses (Table 2), our response rates were often roughly similar to those reported by others who have endeavored to gather information about harvest and sale of other NTFPs. For example, in an assessment of a variety of NTFPs in the coastal PNW, 47.5% of surveyed businesses responded to surveys, with the percentage calculated after removing delivery failures from the totals (Schlosser et al 1991) and Blatner and Alexander (1998) had a 35% useable response rate for surveys sent to NTFP processors in the second year of their study. Our effective response rate for businesses (removing delivery failures) was close to 25%. Schlosser and Blatner (1995), however, calculated a 62.4% response rate for surveys sent to mushroom processors, after removing from the total not only undelivered surveys but also those that were returned indicating that they were no longer in the mushroom business. Our surveys of businesses did inquire about quantities purchased, which, in retrospect, may have been a mistake and may have lowered response rates. For a variety of NTFPs, purchase or sale quantities are increasingly sensitive, at least partly because of recent media attention and sometimes misleading information published about the industries (Blatner and Alexander 1998). Apparently buyers and harvesters for many NTFPs are increasingly reluctant to provide information to researchers, as they are often afraid that their information may lead to increases in regulation, restriction and legislation (von Hagen and Fight 1999). In a survey of moss dealers in NC, Greenfield and Davis (2003) found similarly that most dealers would not provide them with volume or sales information. We know that some moss buyers deliberately fail to maintain records on quantities purchased because of these concerns (J. Peck, pers. comm. based on interviews with numerous buyers); such businesses obviously could not provide us with information.

By sending surveys primarily to relatively large and well-established businesses, we hoped to minimize possible double counting of quantities (e.g., receiving reports from an intermediate-scale buyer and also from a larger-scale buyer who purchased some of their moss from the former). We also assumed that the omitted businesses were too small to affect estimates at the large-scale addressed in this work. This approach also allowed us to avoid contacting those businesses that are most directly involved with harvesters themselves ("mossers" in the Appalachians, T. Thomas, pers. comm. 2004) and hence, potentially least interested in providing information to unknown persons. In the opinion of the Forest Botanical Product Specialist with the National Forests in NC, the moss trade may be even more secretive than the trade in other higher-value and more closely-regulated NTFPs, such as ginseng (*Panax quinquefolius;* G. Kauffman, pers. comm. 2004).

The delivery failure rate that we experienced when we attempted to contact businesses (~ 15%) is consistent, again, with findings by others involved in assessments of NTFP industries. For example, 26 and 17.5% of surveys sent to processors were returned as undeliverable during the 2 yrs of one study (Blatner and Alexander 1998) and19% of surveys sent to processors by

Schlosser and Blatner (1995) were returned as undeliverable. These authors suggest that the large number of undeliverable surveys attests to the often small-scale and entrepreneurial nature of the industry, and also to consolidation that may be underway in some of the processing industries. Almost 60% of a sample of 125 processors of NTFPs known to be operating in 1995 had moved, changed hands, or gone out of business by 1997 (pers. comm. from K.A. Blatner, 1997, cited in van Hagen and Fight 1999).

Harvested Quantities, Permit Numbers, and Trends Over Time

Despite the considerable uncertainty in our estimates of harvested moss quantities, it is clear that large amounts of moss are being harvested from forests in the PNW and Appalachians. If data reported by respondents and available from government sources are proportionally representative, even though incomplete, for the two regions of the country, it is also clear that the PNW supplies more moss to the trade than does the Appalachian region (Tables 3 and 4). Total permitted quantities reported by manager respondents varied year-to-year, with no clear upward or downward trend being reported. The maximum harvest reported by land manager respondents was 166,793 air dried kg in the year 2000 (Table 3). Harvested quantities reported by U.S. government agencies (BLM 1997, 2001; J. Gordon, District Forester, OR BLM, pers. comm. for 2002 and 2003 data; B.J. Anderson, Financial Specialist, WO Financial Management Systems Staff, Functional Team, USFS; www.fs.fed.us/forestmanagement/reports/sfp/index.shtml) for 1997 – 2003 were highest in 2001, when 170,369 air dried kg were reported.

Because no systematic and uniform standards exist for collecting data on harvest quantities and dollar values associated with that harvest for moss (or other NTFPs; Alexander et al. 2002), we must rely on estimation methods such as were used here to acquire additional insights into total quantities being harvested. These estimates put the annual harvest somewhere between 7.6 and 1.9 million air dried kg for 2003 (Table 8). Despite uncertainties associated with these estimates, it is clear that the quantities reported as being harvested based on land manager-issued permits represent only a small fraction of the total harvest (compare quantities in Tables 3 and 4 with estimates in Table 8). Such discrepancies between recorded permitted harvests and actual harvests may be common to NTFPs in general; and result from several factors.

First, recall that only 48% of land managers responded to surveys, many of those respondents did not deal with moss harvesting issues at all, many managers who allow harvesting do not maintain records on quantities being removed, and data provided by respondents were often incomplete. Limitations of data reported by land manager respondents are illustrated by contrasting reported permitted quantities with permitted or purchase quantities revealed by other sources. For example, the National Forests in NC permitted harvest of 13,727 kg, fresh weight, of moss in 2002 (G. Kauffman, Forest Botanical Product Specialist with the National Forests in NC, pers. comm. 2003), which converts to ~ 7,550 air dried kg (conversion factor from Table 1). By contrast, no moss harvest was reported by Appalachian USFS manager respondents for that year (Table 3), perhaps because their records for 2002 were not yet available when our surveys were mailed. However, permitted harvests reported by our respondents for previous years were also much less than 7,550 kg, suggesting that data provided by our respondents do not provide a complete picture of the business. Another example further illustrates the discrepancy between

reported permitted harvests and actual harvests. One moss buyer in VA buys approximately 91,000 kg (air dried weight) of log moss annually and estimated moss harvests from southwestern VA, eastern KY, and northeastern TN may be as much as ten times that amount (D. Richert, SW Region Steward, Dept. of Conservation and Recreation, Division of Natural Heritage, VA, pers. comm. 2003). Either of these quantities exceeds total reported permitted harvest for the entire Appalachian region (Table 3) or USFS Regions 8 and 9 combined (Table 4).

Another factor that contributes to the underestimation of total harvests based on reported permits is that large amounts of moss are harvested legally from lands that do not require formal permits or that do not restrict harvestable quantities per permit (Table 3). For example, forest industries own approximately 9% of the forested land in the U.S. (Alexander 2002), and many of these private land owners issue permits for unrestricted quantities or do not require permits at all, the latter partly to absolve them from liability in the case of harvester injuries occurring on their lands (T. Thomas, Appalachian Root and Herb, pers. comm. 2004). For example, one large-scale moss dealer in WV reported that he buys ~136,000 kg (air dried) of moss per year, largely harvested in WV. He indicated that most of this moss is harvested from timber or mining company land, or from other private land holders, none of which require formal permits for harvesting, and that essentially none of the moss that he buys comes from government-owned land. This individual estimates that his business accounts for approximately 50% of the moss buying in the state of WV, which is one of the major sources for forest moss in the Appalachian region. If we contrast his purchase quantities with the permitted quantities supplied by manager respondents from WV, who reported issuing permits for an average of 2,741 kg (air dried) over the years 1998 – 2001, we see that his purchases dwarf the reported harvest for that state based on permits granted. If we expand to the entire Appalachian region, in fact, we see that the maximum permitted yearly harvest reported by our respondents was only 4,360 kg (air dried; data for 2000; Table 3) and further expansion to USFS Regions 8 and 9 does not close the gap much, with the maximum harvest being recorded as 44,127 air dried kg in 2001 (Table 4). Clearly, despite our best efforts, agency lack of record-keeping, non-responsiveness to surveys, and harvest that is not regulated by the permit system prevented us from obtaining a complete accounting of legally harvested moss quantities.

Illegal harvesting is another factor that contributes to the disconnect between reported permitted and actual harvest quantities. While many harvesters do work within legal guidelines, others do not. In summarizing attitudes of district-level National Forest managers in the eastern U.S., Chamberlain et al. (2002) stated these managers suspect that more people are collecting NTFPs from the National Forests without permits than with them, and that "only a small portion of the actual collection is permitted." Similarly, Peck (1997b) suggested that illegal harvest n NW OR at that time was at least twice the legal harvest, and Greenfield and Davis (2003) reported that several moss harvesters and dealers in NC, when interviewed, estimated that only about one out of 10 moss harvesters applies for a permit for moss harvest. Some of those who harvest without permits may, of course, be doing so legally from lands for which no permits are required, but the common perception is that illegal harvesting is widespread. One NTFP specialist with the USFS estimated that the Forest Service was being paid for only one-fourth of the NTFPs being removed from the National Forests (www.fpl/fs.fed.us/documnts/usda/agib666/aib66609.pdf; accessed Feb. 2004).

Several respondents indicated that some moss harvesters (or the buyer for whom he or she works) obtain a harvest permit from a land manager that does issue permits, but then harvests instead from land that is off-limits to harvesting (and that may have more abundant moss because of harvest restrictions on those lands). The harvester then sells the moss to a buyer, and, if that buyer is scrupulous and checks permits (as some do), the harvester displays the permit and pretends that the moss came from those lands rather than the lands that he or she actually harvested from. Finally, it also seems to be common practice for harvesters (or buyers) to obtain permits for the minimum quantity necessary for purchase of a permit, but then to harvest more than is technically allowed under that permit. The problem of illegal harvesting has become great enough that one major buyer of Christmas and floral greens, including moss, in the PNW, has hired a full-time warden to patrol lands that it leases for harvest use (M. Thompson, Hiawatha, Inc., pers. comm.).

We cannot fully assess the completeness of our respondents' information on permit numbers, however it appears that these data may be reasonably complete, at least for some years. For example, land manager respondents reported issuing a maximum of 410 permits per year across the 6 yrs for which they provided data, with far more permits being reported from the PNW than from the Appalachians (Table 3). Of this 410 permit total, 371 permits were reported by USFS and BLM respondents, which is greater than the total of 318 permits recorded in official BLM and USFS records for the same year (2000; Table 4). Once again, the need to develop an improved centralized system of record keeping is apparent. Not only would improved tracking of permit and harvest information assist attempts to assess the potential ecological importance of moss harvesting, but it would also assist assessments of its economic contributions to land management agencies and the wider economy. Previous work on a variety of NTFPs has attempted to calculate the economic contributions of these businesses to regional or national economies (e.g., Schlosser et al. 1991; Schlosser and Blatner 1995; Blatner and Alexander 1998; Greenfield and Davis 2003; and several Chapters in Vance and Thomas 1997 and Jones et al. 2002), but these assessments have been hampered by the same types of problems that we encountered in conducting this research.

While summaries of dollar values associated with harvest of floral green products, including moss, as a whole have been published for the PNW (e.g., Schlosser et al 1991; Blatner and Schlosser 1997), very few summaries of data particular to moss harvest are available. This lack of information makes it challenging to reach any meaningful conclusion about trends in harvest or sales over time. However, because previous work on the native floral greens business overall suggested that the market for these products in the PNW apparently decreased between 1989 and 1994 (Blatner and Schlosser 1997), we attempted to determine whether trends could be detected for the moss trade in more recent times. Data on numbers of permits for moss harvest provided by our respondents (Table 3) generally do not suggest clear trends in permit numbers over recent years. Exceptions include permit numbers reported by USFS respondents in the Appalachians, which appear to have declined since 1999 (even if 2002 data are ignored, as discussed above). This apparent decline may be caused, in part, by a moratoria imposed on moss harvest on the Monongahela National Forest (Studlar 2003) and a decrease in the number of National Forest districts in NC that permit moss harvesting over these years (G. Kauffman, Forest Botanical Product Specialist, National Forests in NC, pers. comm. 2003). (Note also that permit numbers

recorded by the USFS for Regions 8 and 9 also decreased after 2001; Table 4). The other exceptions may include timber company lands in the PNW, where permit numbers appear to have declined since 1997, and an apparent peak in permit numbers reported by USFS and BLM respondents in 2000 (Table 3; also shown by official USFS records for that year [Table 4]). It is difficult, however, to determine whether the recent decrease in permit numbers reported by these groups is real or is an artifact of data summaries for more recent years being incomplete, and the short-term nature of the data make it challenging to discern real trends. While permit revenues obtained by the BLM in OR and WA generally declined between 1997 and 2003, corresponding numbers of permits did not show as clear a trend, nor did permitted harvest quantities, and no clear trend is suggested in the permit revenues obtained from the National Forest System (Table 4). The BLM in OR and WA reported moss sales of between 27,000 and 205,000 pounds (8,836 and 67,091 air dried kg, respectively; conversion based on factor for PNW moss from Table 1) for the years 1993 – 1995 (Mater 1997). The low end of this range is much lower than quantities reported by BLM for the years 1997 – 2003 (Table 4), while the top end of this range is a bit higher than the more recent data, and no systematic trend over time is apparent. Another report (Blatner 1997) suggests that approximately 3,963 U.S. tons of moss were harvested from western WA and OR and southwestern BC in 1989. This figure converts to approximately 2.6 million air dried kg of moss (using the conversion to air dry weight provided for PNW moss in Table 1), a figure that dwarfs the permitted harvest reported by our respondents (Table 3), but that is within the range for our estimated harvests based on export data (Table 8). Export data provide additional insights into trends over time (see below).

Moss Exports and Export Trends

The value of moss (and lichen) exports, and thus inferred quantities of moss exports, have varied considerably over recent years (Table 8, Appendix 4), with a clear drop in exports (based on U.S. dollars) occurring after the year 2000. By 2003, exports of moss and lichens from the U.S. were worth about $4.2 million dollars, down from a high of about $20.5 million in 1999. This drop contrasts with an earlier trend of increasing export values for these commodities, which began in about 1992 (Alexander et al. 2002). Between 1989 (the first year that the Harmonized Tariff Schedule for tracking exports was instituted; Alexander et al. 2002) and 1991, export values hovered between ~ $2 million and $4 million per yr, similar to current values, but, after 1991, values began a steep upward trajectory. By 1995, these exports had a value of about $14 million per year. Some of the year-to-year variation may relate to volatile prices and some to variation in actual quantities being exported; the HTC data do not allow distinction between these two causes. Price volatility is typical of many NTFPs, owing to shifts in demand, domestic supply, international competition, and other factors (Blatner and Alexander 1998).

Destinations for moss exports have also apparently changed over recent years. As of 2003, the largest importer (in terms of U.S. $ values) was Hong Kong (~ U.S. $ 2.2 million; Appendix 4), followed by Canada, Korea and Mexico (U.S. $ ~697,000; 491,000; and 415,000, respectively). The major European importers in 2003 were Italy and Germany, but their imports were much smaller than those of the previously listed nations (U.S. $ ~ 165,000 and 119,00, respectively). While the Netherlands was the largest importer for several years (Vance et al. 2001; Alexander et al. 2002), the value of exports to this country dropped off precipitously after the year 2000

(Appendix 4). Exports to Japan, China, the UK and several European nations followed a similar pattern. Conversely, Korea and Hong Kong, both currently major recipients of US exports, did not begin importing substantial quantities (values) of this commodity class until 2002 (Appendix 4). In the late 1980's, about 24% of U.S. exports of floral greens from the PNW, including moss, went to Europe with only about 4% going to nations of the Pacific Rim (Walls et al. 1991; Schlosser et al. 1991). As of 2003, only ~ 7.6% of all U.S. moss and lichen exports went to Europe, with nations of the Pacific rim supplying well over half of the market for this commodity (Appendix 4).

What might account for recent changes in exports to various nations? A variety of market forces related to supply and demand, and to international trade regulations may be important. While speculative, interviewees involved with the moss trade in the U.S. suggested that exports from Russia may have increased in recent years, owing to relaxing of trade restrictions; that the supply of moss is great enough at present that European buyers can dictate prices lower than major U.S. suppliers can afford to meet; and that trade agreements among nations in Europe and Scandinavia may force buying of moss from participating nations rather than from the U.S. (M. Thompson, Hiawatha Inc. and T. Thomas, Appalachian Root and Herb, pers. comm. 2004).

Sources for material being exported cannot be directly inferred from the HTC data. While those data include information on the U.S. Customs District from which material left the country (Appendix 4), this District does not necessarily reflect the region of origin for the products. For example, much of the moss from the PNW destined for Europe is shipped from Districts in the eastern U.S., such as NY (Alexander et al. 2002; M. Thompson, Hiawatha Inc., pers. comm. 2004), and districts in FL ship moss from both the PNW and the Appalachians to Europe (Alexander 2002).

Species Composition

Lists of moss and liverwort species found in purchased and confiscated moss samples (Table 7) were generally consistent with the few lists available from other studies (e.g., Peck 1997 a, b: Vance and Kirkland 1997; Peck and McCune 1998; Peck and Muir 2001 a,b; Hutten 1999; Hutten et al. 2001; Studlar 2003) and with responses of bryologists to the survey question about species included in harvests. The lists of target species reported by the authors above also match well our lists of prevalent species, with the number of target species generally being smaller for Appalachian material (~ three species are most commonly considered targets there; *Thuidium delicatulum, Hypnum imponens* and *H. curvifolium*) than for PNW material (~ seven species are most commonly considered targets there; *Antitrichia curtipendula, Eurhynchium oreganum, Frullania tamarisci* subsp. *nisquallensis, Isothecium myosuroides, Neckera douglasii, Porella navicularis* and *Rhytidiadelphus loreus*). While our total species list was slightly longer for PNW than for Appalachian material (34 *versus* 28 moss and liverwort taxa for the two regions, respectively) another study that focused on moss harvested in WV and included material rejected by the buyer as unsuitable found many more taxa (65 mosses and 13 liverworts), with most of these being "incidental" species that were present only in small amounts (Studlar 2003).

Some surprises did emerge from the assessment of species found in commercial and confiscated material, however. These relate to the prevalence of various substrates that the harvested species were taken from. For example, previous work has assumed that most of the harvest from the PNW is of epiphytic species (see Peck publications, cited above, and Vance and Kirkland 1997). Inspection of material from the PNW in the current work, however, found that many samples included species that are most commonly found on logs or on the forest floor. An illegal moss harvest incident in Olympic National Park, WA, targeted both epiphytic and log substrates, despite the fact that buyers generally prefer epiphytic material because it is cleaner and often holds together better than material harvested from other substrates (J. Peck, U MN and M. Hutten, Olympic NP, pers. comm. 2003). It is not clear whether or not a change in harvester behavior has occurred over recent years (e.g., increased emphasis on harvesting from substrates other than trees and shrubs). In addition, if a change in harvester behavior has occurred, it is not clear whether it has resulted from changes in market preferences, reduced supplies available on the formerly preferred substrates (trees and shrubs), or other causes.

Logs are assumed to be the preferred substrate for moss harvest in the Appalachians, with the material variously sold as "sheet moss," "carpet moss" or "log moss." Indeed, logs were the most common substrate for species found in Appalachian material, although one of the prevalent species, *Thuidium delicatulum*, also occurs commonly on rock and some material of this species had clearly been harvested from this substrate, consistent with Studlar's (2003) findings from material in WV. In fact, Studlar (2003) found that 79% of mats of this species (which comprised 65% of the total cover across all species she examined) had been collected from rocks rather than from logs, and that most of the incidental mosses and liverworts in the samples were associated with this species. She suggests that harvesters in that area seem to be focusing increasingly on rock substrates, and that overharvesting may have driven this shift from logs. Alternatively, the shift may be caused by changing forest practices in the region, which leave fewer logs on the forest floor than did past practices (Studlar 2003; T. Thomas, Appalachian Root and Herb and G. Kauffman, Forest Botanical Product Specialist with the National Forests in NC pers. comm. 2004). Many of the species found in our samples occur on the forest floor or on rock, often in addition to occurring on logs, possibly suggesting that harvests occurred from a variety of substrates, consistent with such shifts in harvester practice. Studlar's (2003) assessment of taxa found in bags purchased but then rejected by a WV moss dealer also revealed species collected from mesic limestone cliffs, a substrate not commonly associated with the commercial moss harvest trade but that supports many incidental species (including vascular species) that are not marketable.

Regional differences in preferred substrate for harvest may influence the regional differences in mean moisture content of fresh material that we used in our unit conversions (45% and 28% moisture content for Appalachian and PNW material, respectively; Table 1). More moisture-retaining substrata, such as bits of wood, are likely to be included in mats harvested from rotting logs than in those harvested from living trees and shrubs. Further, pendant epiphytic mats probably lose water more readily than do the cushions, wefts, and mats of moss harvested from logs. Relatively dry summers in the PNW are conducive to moss harvesting during that season, as material then weighs less and is easier to haul out of the forest, whereas seasonal differences in moisture regime are less pronounced in much of the Appalachian region.

It is reassuring that none of the species identified in our samples are species of concern, although it is important to remember that our sample was fairly small (54 samples) and not necessarily fully representative of products being sold from either region. This, coupled with the fact that most species of concern are uncommon, suggests that a larger sample might have revealed the presence of some sensitive species. It is noteworthy, however that sensitive bryophyte species have generally not been reported in harvested material inspected by others to-date (Hutten 1999; Hutten et al. 2001; Studlar 2003), in previously published lists of species collected from substrates that harvesters prefer (e.g., Peck publications and Vance and Kirkland 1997), nor were any found in a survey of species present on 50 logs in NC (G. Kauffman, Forest Botanical Product Specialist with the National Forests in NC, pers. comm. 2004). The only exception was the moss *Antitrichia curtipendula*, commonly found in material harvested from the PNW, and formerly listed as a survey and manage species under the Northwest Forest Plan (USDA and USDI 1994, USDA 1995). This species was listed not because it is rare, but because it is an important component of old-growth forest ecosystems; subsequent decisions have, however, removed it from the list of candidate survey and manage species (USDA and USDI 2003). Because most harvesters do not distinguish between species when harvesting (J. Peck, pers. comm. 2003, based on conversations with numerous harvesters; T. Thomas, Appalachian Root and Herb, pers. comm.), it is likely that rare species are sometimes included in harvests.

While sensitive species have not, by and large, been detected in harvested material in the past, possible changes in harvester behavior with regard to choosing sites for harvest and the tendency for sensitive species to be found patchily and in unusual habitats suggest that harvests may not continue to be as free of such species as they appear to be currently. In particular, future studies should watch for the occurrence of species that occur in moist habitats, such as some limestone cliffs, seeps, and riparian areas. These habitats support a high proportion of the bryophyte species of concern (e.g., the liverwort *Megaceros aenigmaticus* in the Appalachians [D. Smith, pers. comm. 2003] or the moss *Encalypta brevicolla* var. *crumiana* in the PNW [USDA 1995]), so that harvest in such areas is more likely to include them as incidentals. Harvest in such areas often also results in collection of species that are not commercially desirable and are rejected by buyers (Studlar 2003); such waste makes it even more important that such habitats be excluded from commercial harvest. Another habitat that supports bryophyte species of concern in the PNW is old-growth forest (e.g., *Iwatsukiella leucotricha, Schistostega pennata* and *Tetraphis geniculata*; USDA 1995; Hutten et al. 2001); for this and other reasons (see below), commercial harvest should be prohibited in such forests.

Lichens were included in the list of incidental species from the PNW but not the Appalachian material (Table 7). None of the lichens found in our samples were species of particular concern. Harvests may occasionally include lichens of concern, however. Vance and Kirkland (1997) found four lichen taxa that were listed at that time as species of concern under the Northwest Forest Plan (USDA and USDI 1994) in their sampling of harvestable epiphyte mats from *Acer circinatum* in western OR (species names were not included in the publication), and Peck (1997a) found seven lichen taxa that were similarly listed. Thus, studies of species found in harvested material should continue to include lichens, as sensitive species may be harvested inadvertently along with target moss (or lichen) species.

The Status of the Moss Resource, Sustainability of Harvesting and Potential Ecological Impacts of Commercial Moss Harvesting

There are many unknowns related to the sustainability of commercial moss harvest and potential ecological and economic impacts associated with the trade (e.g., see USDA 2001). The level of uncertainty about these matters was clearly expressed in responses to our surveys. Each interest group that we surveyed expressed some concern about the status of the harvestable moss resource (Table 5), although the only group from which a majority of respondents indicated concern was bryologists and botanists (64% believed that volumes being harvested were of concern). While most respondents from the business community believed that supplies of moss were stable, the percentage that believed that supplies were decreasing was substantial ($\geq$ 25%). Some of these respondents indicated, however, that supplies are decreasing not because of overharvesting, but because substrates are in increasingly short supply (e.g., logs in the Appalachians, hardwood trees and shrubs in the PNW) owing to forest management practices, or because restrictions on harvest in some areas force overharvesting from areas still open to harvest. That is, concerns on the part of the business community were focused more on the role of legal or habitat constraints than on the possibility that removal rates may be faster than rates of regrowth. Greenfield and Davis (2003) report that some harvesters with whom they spoke in NC indicated that it is becoming more difficult to find commercially harvestable log mosses, with a consequent increase in their travel time to suitable sites.

We anticipated that, if concerns existed about harvestable moss supplies, these concerns might be reflected in attitudes about present levels of regulation of the resource. Concerns should be expressed as feeling that present levels of regulation are inadequate, however the only group for which a significant percentage (33 %) felt this way was, perhaps surprisingly, businesses from the Appalachians (N was only two respondents out of six, however; Table 5). Most respondents across all groups who had an opinion on this question felt that present levels of regulation are adequate and generally small percentages felt that regulations are currently excessive (the only group with a significant percentage believing this was businesses from the PNW, where two out of eight respondents expressed this belief). Overall, responses to questions about levels of regulation over moss harvest did not suggest that concerns about sustainability of harvesting were widespread.

Nevertheless, a variety of concerns have led to the imposition of harvest moratoria on some lands. These concerns include depletion of the moss resource and associated loss of ecosystem functions played by mosses in forests, threats to sensitive species, lack of information on which to base sound permitting decisions, and lack of enforcement personnel. While more moratoria may exist than we learned of, we know that they are presently in place on the Monongahela National Forest in WV; the Chattahoochee National Forest in NC; lands managed by Simpson Resource Co., in WA; most of the Eugene District of the BLM in OR; and on three districts on National Forest lands in NC (the Pisgah and Appalachian in the Pisgah National Forest and the Wayah in the Nantahala National Forest) (Studlar 2003; G. Kauffman, Forest Botanical Product Specialist with the National Forests in NC, pers. comm.; www.edo.or.blm.gov/planning/nepa/siuslaw/ce/CE-0-08.pdf accessed March 2004); D. Taylor, pers.comm.). Respondents also indicated that a moratorium is likely to be imposed on the Cherokee National Forest in TN, and no harvesting of any NTFP is allowed on state forest lands

in some states, such as NY. Problems with enforcing moratoria exist, however, owing largely to the shortage of personnel and the large, often well-roaded land areas involved. Further, some suspect that the existence of a moratorium on one land area promotes higher rates of harvest from nearby areas not included in the moratorium's boundary (T. Thomas, Appalachian Root and Herb, pers. comm. 2004).

Concerns about impacts of moss harvesting range from the ecological to economic. One of the most fundamental concerns relates directly to the moss resource itself, and includes both ecological and economic considerations. This concern involves rates at which mosses reaccumulate following harvest in comparison to the time elapsing between return visits to a site. Only a few published studies have yielded information on reaccumulation rates, but, fortunately additional studies are on-going and should yield useful results within a few years. Rates of reaccumulation estimated for epiphytic mosses in western OR are generally slow, but depend on site conditions (particularly moisture status); a range of between 10 and 30 yrs has been estimated for commercial rotation lengths (Peck and McCune 1998, Peck and Muir 2001b). These rates were estimated retrospectively, by removing and weighing moss mats and aging the stems from which mats were taken, thus a number of uncertainties are associated with the estimates (*op cit.*). Experimental stripping of tree and shrub stems in the PNW and of logs in the Appalachians, with follow-up assessments of moss reaccumulation will lead to more definitive estimates of commercial rotation lengths, and several of these studies are on-going (described in Vance and Kirkland 1997; Peck and McCune 1998; Cobb et al. 2001; Peck and Muir 2001a; also by F. Duran, Siuslaw N.F., pers. comm.; R.W. Kimmerer, SUNY Syracuse, pers. comm 2002; and G. Kauffman, Forest Botanical Product Specialist with the National Forests in NC, pers. comm. 2004). Preliminary results from all of these studies suggest that the method of harvest greatly affects reaccumulation rates. Most re-growth occurs by lateral extension from mosses left on the harvested surface or from those bordering the disturbed area, rather than through colonization by spores and subsequent establishment and growth of new individuals. If the substrate is harvested following by rolling moss off a branch or log in a sheet, then rates of reaccumulation are likely to be much slower than if harvest leaves islands of residual moss in patches within the harvested area (as in harvest by a "swipe" rather than "roll" or "peel" method). When mosses are rolled or peeled thoroughly off surfaces, preliminary results suggest that recovery rates may be as long as 20 – 30 yrs, depending on the environment and the species, but when islands of moss are left behind, recovery may be speeded (e.g. to ~ 10 – 12 yrs; G. Kauffman, Forest Botanical Product Specialist with the National Forests in NC, pers. comm. 2004). In addition, two studies following reaccumulation of mosses on substrates that were actually stripped by harvesters, including one study that includes attempts to foster reaccumulation by attaching transplants to harvested substrates, are in place (Hutten et al. 2001; F. Duran, Siuslaw N.F. and J. Peck, U MN, pers. comm. 2004), and will yield useful insights. Finally, anecdotal reports from WV suggest that at least some "log moss" sites have profitably been reharvested within 10 yrs of prior harvest (T. Thomas, Appalachian Root and Herb, pers. comm. 2004).

Another concern about direct impacts associated with commercial moss harvest involves the possibility that harvest and subsequent regrowth will change the composition of moss communities. Factors such as differential growth rates and forms, dispersal abilities, and degrees of removal (related to harvest techniques and the extent to which various species adhere to

substrates) are all likely to affect the composition of mats that develop after harvest (USDA 1995, Vance and Kirkland 1997, Peck 1999, Cobb et al. 2001; Peck and Muir 2001a, Studlar 2003). Further, harvest may result in desiccation of remaining small colonies and to fragmentation of populations, potentially contributing to changed communities post-harvest (USDA 1995). If the moss communities that develop after harvest are substantially different from those that existed pre-harvest, impacts are not necessarily limited to changes in the moss community itself, but may extend to affect the commercial value of the moss resource and a variety of ecosystem components, depending on the nature and degree of community change. Fortunately, the reaccumulation studies cited above are focused not only on measuring reaccumulation rates, but will also yield data on communities that develop over time, and thus will provide insights into the importance of this potential impact.

Additional concerns about impacts of moss harvest relate to the important ecosystem roles played by mosses, and thus involve indirect consequences of moss removal or changes in species composition. Mosses serve many roles in forests, including roles in nutrient retention, hydrological buffering, soil stabilization, provision of habitat for numerous arthropods and vascular plant species and of nesting materials for birds and mammals, provision of seed and spore banks, and others. Information on effects of commercial moss harvesting on these ecosystem components and functions is not available, but is urgently needed to inform management decisions.

Conclusions and Recommendations

The commercial moss industry in the PNW and Appalachian regions of the U.S. is important economically, resulting in millions of U.S. dollars in sales each year and contributing to large numbers of jobs in the U.S., from harvesters to buyers to suppliers, wholesalers and retailers. This industry is also important ecologically, as it is based on the harvest of thousands of metric tons (air dried) of moss each year from forests in these regions, with only a few species constituting the bulk of the harvest. Despite the fact that millions of dollars and kgs of moss are involved, few people realize that the business exists at all, much less understand its importance. Little is known about the basic biology of the primary target species, or about their ecological roles, and this lack of knowledge makes it impossible to understand, without long-term studies, the impacts of harvest on their populations or on the ecosystems that they are part of. Similarly, we do not have sufficient knowledge about "incidental" species that comprise a portion of the harvest to determine whether commercial harvesting affects their populations or ecological roles. We also have little knowledge about the size of the commercial moss resource in our forests. These unknowns impede the ability of policy makers and land managers to make wise decisions concerning moss harvest policies

Similar questions exist for most other NTFPs, and a variety of researchers, government policy makers, and interest groups have worked in recent years to develop policies towards NTFP management that address both ecological and socioeconomic challenges associated with NTFP harvest and sales (see reviews in von Hagen et al. 1996; Vance and Thomas 1997; von Hagen and Fight 1999; Kauffman et al. 2000; USDA 2001; Alexander 2002; Chamberlain et al. 2002; Jones et al. 2002; Greenfield and Davis 2003). While not a focus of the present research, socioeconomic aspects of the NTFP business are complex and difficult to unravel, particularly

because they often involve issues related to employment of recent immigrants to the U.S., some of whom are working illegally in the country, because many workers are part-time and move from job to job, and because products follow diffuse, frequently changing, and often undocumented pathways from forests to markets (e.g., Schlosser and Blatner 1990; Schlosser et al. 1991; Johnson 1992; Thomas and Schumann 1993; Schlosser and Blatner 1995; Blatner and Alexander 1998; Freed 1998a; von Hagen and Fight 1999; Alexander 2002; Greenfield and Davis 2003). Further, NTFP industries are often centered in rural, economically-depressed areas, where they contribute substantially to local economies (*op.cit.)* such that policy decisions about harvest practices can have significant consequences.

The recommendations (and rationale) concerning commercial moss harvest listed here are particular to the moss harvest industry, but, in many cases, apply to other NTFP industries as well. They are based on findings from the project reported here and on related literature concerning NTFPs. Recommendations are broken loosely into the categories of information needs and management needs, although there is crossover between categories. Some of the recommendations could be implemented inexpensively, while others would be more costly. Considering the ecological and economic importance of the moss resource, however, all are warranted.

Information Needs

(1) *Obtain information on the size of the resource and its reaccumulation (rate and species composition) after harvest*. This information is lacking, for the most part (but see Peck and Muir 2001a and Kerns et al. 2002, as well as works cited in the discussion of the status of the moss resource, above, for suggested methods). The moss resource is patchily distributed on the landscape, being responsive to overstory conditions, site humidity, and other factors (e.g., Peck and Muir 2001a). This patchy distribution means that moss harvest guidelines must be tailored quite specifically for each area, based on quantities and species of moss present, and productivity of the site for mosses. Obviously, wise management requires area-specific inventories of the moss resource. Further, we know very little about the basic biology of target or incidental species, nor about their population biology, the rate at which their preferred substrates are produced in forests (e.g., rates of log recruitment to the forest floor in Appalachian forests; G. Kauffman, Forest Botanical Product Specialist with the National Forests in NC, pers. comm. 2004), nor how rapidly new substrates are colonized. This information comprises an essential basis for sustainable management of the resource, and sound ecologically-based decisions cannot be made until these information gaps are closed. The Hebo District of the Siuslaw National Forest in western OR, in cooperation with the BLM, is funding a long-term study on approximately 900 ha which is intended to provide information on these parameters and others (F. Duran, Siuslaw N.F., pers. comm. July 2004).

(2) *Conduct inventories and monitoring in cooperation with moss harvesters*. Harvesters can inform researchers about which species (or "types" of moss) are commercially important, so that inventory can focus on the resource actually being harvested. Harvesters can also demonstrate harvest techniques, so that studies of reaccumulation will be based on substrates that have been harvested using standard methods. Ethnographic surveys of harvesters and small-scale buyers could help to fill in understanding about past and current harvest methods, harvested substrates, and species, and, potentially, even about reaccumulation

rates, based on years of harvester experience. In many cases, harvesters could profit from an association with research efforts, as when they are allowed to sell material that is harvested for experimental purposes. Further, the association of researchers (or managers) with harvesters can help to build trust between these groups; trust which is sorely lacking in most cases. See case studies described by the Institute for Culture and Ecology (http://www.ifcae.org) and in Trinity Project Management Team 1992; Pilz et al. 1999; and vog Hagen and Fight 1999.

(3) *Educate harvesters, and reciprocally learn from harvesters, about harvest techniques that are most sustainable. Include training in recognition of sensitive species, and about why it is important to avoid harvesting certain species and in sensitive habitats.* As for recommendation # 2, harvester knowledge should be taken into account, and doing so is likely to make education efforts more acceptable to harvesters. While uncertainties remain about which harvest techniques lead to fastest reaccumulation of desirable species, we know enough to begin this education. Harvesters who have been involved in the trade for many years undoubtedly have accumulated knowledge in this area. Pilz et al. (1999) point out that some of this education can be accomplished when harvesters apply for harvest permits, and they describe case studies that testify to the effectiveness of such educational programs. Harvester education could be coupled with harvester involvement in inventory and monitoring studies, described in recommendation # 2, above. Such interactive efforts should enhance relationships of harvesters with land managers, law enforcement officers, and researchers as a side benefit of the educational programs (see also Freed and Davis 1997, von Hagen and Fight 1999). Such education also should reduce harvest of species that are rejected at buying time, and hence are sacrificed for no economic return (see Studlar 2003). Harvesters should be provided with illustrated lists of species of concern in each area, and harvest of such species should be made illegal, if it is not currently considered so. Ready availability of illustrated guides to sensitive species would also enhance knowledge of managers, law enforcement officers, and moss buyers about which species to watch for in harvested material. Lists should be continually revised as new information concerning species' status becomes available.

(4) *Conduct additional research on ecosystem roles provided by mosses and assess whether commercial harvesting adversely affects any of these functions.* While we know a good deal about many ecological roles provided by mosses in forests (see recent review in Studlar 2003), there is still much to learn, and much of what we already know (or suspect) requires quantification. For example, do some invertebrate species depend on moss for habitat, and are these species adversely affected by moss harvesting? How important are mosses in the hydrologic regime of forests, and is that role compromised by commercial moss harvesting? Such knowledge will enhance the creation of sound harvest standards and guidelines.

(5) *Analyze communities of species associated with moss mats to determine whether interstate or international transport of untreated moss may cause introductions of species that could become problematic.* Concerns have been raised about interstate and international transport of moss, as it is not usually treated to destroy any associated creatures that may be in the mats. Most treatment consists simply of air drying the material. A study of 30 mats harvested for experimental purposes in western OR found ~125 arthropod taxa within these mats (Moldenke and Peck, unpublished report on file at Oregon State University, Corvallis, OR). Are any of these associated creatures likely to create problems when they are introduced to new areas with the moss in which they travel?

(6) *Explore the possibility of cultivating mosses for commercial purposes.* If commercially desirable moss species can be cultivated under conditions that encourage rapid growth, emphasis on wild-harvesting of moss might be diminished. Commercial-scale cultivation of some other NTFPs, such as ginseng (*Panax quinquefolius*) is proving feasible (e.g., Bourne 2000), and the possibility that moss could be cultivated at commercial scales warrants exploration. One small pilot study is on-going at a penitentiary in WA (Nadkarni2004), and similar efforts should be undertaken elsewhere.

(7) *Improve tracking of and record keeping on harvested quantities and locations, and standardize reporting formats.* This is important not only for evaluating sustainability of harvest and updating permit guidelines, but also for informing government and other officials about the importance of the moss trade. If NTFPs are to receive the attention (e.g., allocation of resources towards sustainable management, enforcement, and monitoring) from government and other land management agencies that they deserve, the agencies need information on the ecological and economic significance of commercial moss harvest (Chamberlain et al. 2002). However, as the research reported here makes clear, most moss harvest is either undocumented or documented in diffuse ways, and using variable units of measure, that make thorough compilations of harvest records impossible to achieve. Because much of the economic activity associated with NTFPs is part of the "informal economy," (Alexander 2002), few to no data are kept on these activities and they remain largely invisible to both policy makers and analysts. At present, some land management agencies track moss harvest permits (e.g., some BLM and USFS districts), however not all do so. However, moss harvest permit records are not reliable, in themselves, for determining amounts of moss being harvested. Such records may be a reasonable indicator of relative market size, demand, and movement (Alexander 2002), but, under current systems, they are not closely tied to information on amounts actually harvested. In some states, such as OR, buyers are expected to keep track of the purchases when harvesters bring moss in to sell {ORS 165.813(3)}, however enforcement of this law is lax. Further, while buyers are to maintain purchase records on an annual basis, the information is not collected by the state (S. Alexander, USFS, pers. comm. 2003). Up-to-date records on quantities of moss harvested annually, tied to mapped locations of harvests, would, ideally, allow land managers to distribute harvests across the landscape in a sustainable fashion, given understandings about reaccumulation rates.

(8) *Facilitate tracking of quantities of moss being sold domestically and by export through the assigning unique codes to forest moss* (separate from peat moss and other decorative NTFPs). Von Hagen and Fight (1999) suggest that unique standard industrial classification (SIC) codes be assigned to individual segments of the NTFP industry. Similarly, the Harmonized Tariff Schedule code system should be revised to enable tracking exports of forest moss as a unique category rather than as part of the combined category that is presently used. As for recommendation # 7, above, this would increase the transparency of the business and would facilitate recognition of its importance, particularly for regional economies.

<u>Management Needs</u>

(1) Couple moss harvest permitting with a commitment by the land management agency to monitor periodically the resource to assess effects of harvesting (Schlosser et al. 1992).

Such monitoring is common following other kinds of resource extraction activities (e.g., timber, fish, big game species), and should be extended to NTFPs. Many land manager respondents recognized the importance of such monitoring and indicated frustration with the shortages of money and personnel that make such monitoring impossible for their agencies.

(2) *Include standards and guidelines for moss harvest in National Forest Plans and similar planning documents for other land management agencies*. The USFS and BLM are expected to manage forests for multiple uses, and the USFS has outlined a national strategy for special forest products in broad terms (USDA 2001), as have some BLM offices (e.g.,USDI 1993, and see Antypas et al. 2002). However, a recent survey found that only 7 of 32 management plans for National Forests in USFS Regions 8 (southern) and 9 (eastern) included NTFPs at all (Chamberlain et al. 2002). Plans that did include them devoted an average of less than one-half of one percent of text to them. This lack of attention to NTFPs results, in part, from lack of knowledge about the magnitude of harvest and economic returns, as discussed above. House Bill 2466 section 339, under the 106th U.S. Congress, details a Pilot Program of Charges and Fees for Harvest of Forest Botanical Products for National Forest system lands in the U.S., which may improve the situation for these lands. Under this bill, National Forests will be required to collect not less than the fair market value for forest botanical products harvested, pay for costs of administering harvest programs (including environmental assessments) from permit fees, and not allow harvest in excess of sustainable harvest levels (Chamberlain et al. 2002; Bagby et al. 2003). This piece of legislation, when implemented, could go a long way towards improving knowledge and management of the moss (and other NTFP) resource. The Codified Federal Regulations (CFRs) pertaining to this bill have been sent out for Tribal consultation (summer 2004), after which the USFS will prepare for Federal Register posting for review and comment. It is clear that managing forests for timber and NTFPs (along with other values) could enhance economic, social, and ecological returns from forest management (Weigand 1997, cited in van Hagen and Fight 1999).

(3) *Include management for the moss resource in silvicultural prescriptions.* Many region-specific steps could be taken to foster the development and retention of moss in our forests, and many of these steps are compatible with other forest management goals. In the PNW, for example, hardwood trees and shrubs are the preferred habitat for much of the harvestable moss (e.g., Peck 1997b), and silvicultural prescriptions can, in many cases, be devised that will retain and encourage such species (Vance et al. 2001). Hardwood retention is being called for in PNW forests for other reasons as well (e.g. Muir et al. 2002), including the importance of such trees and shrubs as habitat for birds and arthropods, hence such management could achieve several objectives simultaneously. As another example, logs on the forest floor are preferred habitat for many of the commercially important Appalachian moss species, yet current management approaches often remove, or chip, such woody debris, decreasing available habitat (T. Thomas, Appalachian Root and Herb, pers. comm 2004; G. Kauffman, Forest Botanical Product Specialist with the National Forests in NC, pers. comm. 2004). Management that leaves coarse woody debris *in situ* and encourages its production could be important for the moss resource (and for other ecosystem attributes) in that region of the country. Widespread use of clear cut harvesting of timber reduces the availability of the shaded environments in which many commercially-important mosses thrive. Alternative timber harvest strategies that leave remnant trees could be helpful for mosses as well as for fostering structural and compositional diversity in forests (see USDA and USDI 2001).

Finally, some land manager respondents indicated that they currently allow moss harvest only in areas on which timber harvest (or other disturbances, such as road building) are about to occur. Permitting could direct harvesters to such areas, however, permit guidelines should require that significant percentages of moss be retained on substrates that will remain after the disturbance (e.g., on shrubs), to serve as sources of propagules for establishment of new mats.

(4) *Identify and protect from harvest areas known to host concentrations of sensitive species or that comprise particularly sensitive habitats.* In many cases, considerable knowledge exists about locations for sensitive species, or about the habitats in which they are most likely to occur. Often, certain types of areas constitute "hotspots" of species diversity, and these areas should be located on maps and the maps should be provided to harvesters, along with education about why harvest in these areas should be avoided (Hutten et al. 2001; see also recommendation # 3, above). For example, in the PNW, old-growth forests, old remnant conifers in younger conifer stands, rock outcrops, and riparian areas constitute such diversity hotspots for mosses (and lichens) (Muir et al. 2002), and harvest should avoid such areas and features. In the Appalachians, habitat hotspots for mosses include riparian areas, seeps and limestone cliffs (Studlar 2003). In some cases, it is to a harvester's advantage to avoid harvesting in such places anyway, as species that are dominant there may not be commercially desirable species (Studlar 2003).

(5) *Improve enforcement of harvest regulations*. Illegal harvesting is believed to be widespread, and this is enabled, in part, by a lack of enforcement capability on the part of land management agencies and other enforcement officials. For example, each officer on the National Forests in NC patrols ~62,500 – 83,300 ha (G. Kauffman, Forest Botanical Product Specialist with the National Forests in NC, pers. comm. 2004), and cannot possibly detect or apprehend most of the moss thieving that takes place, nor check with harvesters about where they harvested from and which species they took. Many land manager respondents indicated their frustration with their current lack of enforcement capabilities. More money and personnel are needed for enforcement at all levels; from patrolling forests to checking purchase records at small buying sheds and on up the purchase and sales chain. Enforcement could be facilitated if forest patrol personnel were armed with maps illustrating areas that are reserved from harvest so that they could concentrate efforts in those areas. In the case of National Parks, where no harvesting is allowed, enforcement personnel could be furnished with maps showing areas with lush – and accessible – moss that pickers would be likely to target (Hutten et al. 2001). We did not collect information systematically on fines levied against illegal harvests, but we learned enough to state that the severity of fines varies greatly from one land management unit to another, and that some are not severe enough to serve as serious deterrents to illegal harvesters (e.g. $250 plus court costs for poaching moss on some lands in VA; D. Richert, pers. comm. 2003). Serious fines, or even jail terms, are likely to decrease the frequency with which illegal harvesting takes place.

(6) *Explore the utility of alternative arrangements for allowing harvester access to sites where harvest is deemed acceptable*. Harvesters gain legal access to forest lands by a variety of means, with one of the more common being individual acquisition of short-term harvest permits for particular areas. In some cases (perhaps an increasing number of cases over recent years; Lynch and McClain 2003), buyers lease large land areas from which a variety of NTFPs can be harvested, and harvesters are then hired directly by buyers to procure the material. However, such arrangements, particularly the former, do not necessarily foster

good stewardship practices, as the harvester (or buyer) does not have a long-term commitment to protecting the resource on a particular piece of ground. Improved understanding of harvester characteristics, as through ethnographic surveys, could give insights into relationships between land use agreements and sustainability of harvest practices; it is likely that harvesters understand well what kinds of land tenure rights result in what kinds of harvest practices (S. Alexander, USDA Forest Service, pers. comm. 2004). While there is reluctance on the part of some land owners to grant long-term leases to individuals or companies, owing largely to concerns about liability for harvester injury (M. Thompson, Hiawatha, Inc., and others, pers. comm. 2004), some long term arrangements show promise as mechanisms for improving stewardship of the land and the resource. In addition to having a vested interest in not overharvesting the resource and in leaving sufficient inoculum for regrowth, when a harvester has a long term lease for particular lands he or she can become "the eyes and ears" of the forest, and can assist law enforcement efforts. A variety of alternative models for harvester access to lands have been proposed and are being tested, and many share a focus on conservation-based community development. Such development is based on the concept that ecological integrity, economic opportunity, and community are closely linked and can be fostered simultaneously (von Hagen and Fight 1999). Many of these schemes share an emphasis on development of improved relationships and trust between harvesters, buyers, land managers, law enforcement personnel, the research community, and the public. As our attempt to communicate with various parties in the moss business made clear, and has been widely reported by others in studies of other NTFPs, trust is badly lacking at present. A systematic review of such conservation-based community development schemes would be timely, and would minimize the possibility of groups "re-inventing the wheel" when it comes to creating such systems. See discussion of pros and cons associated with various models, including conservation-based community development efforts, stewardship contracts, NTFP certification programs and long-term leases in Johnson 1992; Trinity Project Management Team 1992; Schlosser et al. 1992; Thomas and Schumann 1993; Freed 1998a; Pilz et al. 1999; von Hagen and Fight 1999; Kauffman et al. 2000; Ringgold 2002; Lynch and McLain 2003, and other sources listed in Appendix 6).

(7) Approach regulation of moss harvest on a regional, rather than land-management unit, scale. Cooperation between neighboring land management units in regulation of the moss trade would be helpful in several ways. First, the various management units could share the work of developing locally-appropriate permit guidelines and regulations. Second, common guidelines and regulations within a region would reduce harvester confusion and uncertainty about which guidelines are in place for the area currently being harvested. Third, such regional uniformity would simplify the work of buyers and law enforcement officers as they track permits and purchases. Regional uniformity would also facilitate protection of the moss resource, whose dynamics occur at regional, not land-management unit, scales, and would be particularly effective if guidelines for a given region were set to protect the moss vulnerable portions of the moss resource. Finally, regional agreements would decrease a current problem that can be created when one land management unit in a region declares a moratorium on moss harvesting. A moratorium in one area can increase intensity of harvest on nearby areas (T. Thomas, Appalachian Root and Herb, pers. comm. 2004). An example of a cooperative regional effort is found on the Hebo District of the Siuslaw National Forest in western OR. The USFS and BLM are cooperating here on a long term study, initiated in the mid-1990's, in which several questions about moss harvest are being addressed, including

determining which species are included in harvests, the size of the biomass inventory, and post-harvest reaccumulation rates following various harvest protocols. Results of the study will be used to refine moss harvest permit decisions for both agencies in the region (F. Duran, Siuslaw N.F., pers. comm. July 2004).

In conclusion, we quote from Peck (1997b): "Although the harvest of moss as a commercial forest product is distasteful to most bryologists, we would be errant to presume that this harvest will simply cease to exist. If we are to protect the bryophyte communities being affected, we must work to help…land managers regulate this industry." Our ability to help land managers make informed harvest decisions that will lead to both ecological and economic sustainability is hampered by lack of information, however, as the current study makes clear. The ecological and economic importance of forest mosses suggests that, until informed by improved data on harvested quantities, the size of the resource available for harvest, the basic biology of harvested species, and the ecological impacts of commercial harvest, land managers would be wise to be conservative in their permit decisions.

Acknowledgements

Funding for this work was provided by the U.S Fish and Wildlife Service through a Cooperative Agreement with the USGS Forest and Rangeland Ecosystem Science Center (Award No. 02033WS008). Patricia L. Ford of the U.S. Fish and Wildlife Service was instrumental in developing the concept for the work and, together with G.L. Larson, facilitated the funding agreement. The past work of J.L. Peck laid the groundwork for much of the research reported here. Moss and liverwort species were identified by J.L. Peck and D.K. Smith, and their efforts are gratefully acknowledged. K. Sikes and K. Norman located contacts from within the three surveyed groups, sent out surveys, recorded responses, tracked down obscure reference material, and summarized findings; their expertise and persistence made this project possible. Several individuals were particularly generous with their time and provided valuable information or moss samples, including B.J. Anderson, S. Alexander, M. Antoine, P. Davison, J. Greenfield, M. Hutten, G. Kauffman, C. Kuhns, C. Marbet, B. McCune, D. Richert, D. Rubino, A. Smith, S. Studlar, D. Taylor, T. Thomas, , M. Thompson, D. Taylor, N. Vance, D. Wagner, R. Walker, and M. Wineteer. Approval to conduct this research involving human subjects was granted by the Oregon State University Institutional Review Board (IRB). This report benefited from comments provided by S. Alexander, F. Duran, B. McCune and S. Studlar.

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Appendix 1 --Cover Letters and Surveys Sent to Interest Groups

Bryologist/botanist Cover Letter:

Dear Dr. _____:

We are involved in a project that is focused on the commercial harvest of moss in the Pacific Northwest and Appalachians. The goal of the project is to gather and summarize information on the commercial harvest of living moss from forests in these regions (e.g., moss growing on fallen logs, tree boles, shrubs, and the surface of the forest floor). As you are probably aware, moss is of considerable (and growing) commercial importance, largely for the florist/horticulture trade (e.g., for use in topiary, wreaths, coverings over soil in potted plant arrangements, and so forth). While it is believed that the harvest and sale of this "special forest product" has a commercial value in the millions of dollars, little is currently known about how much moss is actually being removed from the forests or about how much can be harvested sustainably. Some work from western Oregon suggests, however, that mosses in many circumstances reaccumulate quite slowly, while rates of removal are much faster. In addition, some of the species harvested are species of concern.

Working with funding provided by the US Fisheries and Wildlife service (through the US Geological Survey), we hope to determine:

- how much moss is actually being harvested and sold,
- the relative importance of export versus domestic trade,
- which species comprise the bulk of the material harvested from the Pacific Northwest and the Appalachians, and
- whether harvested material includes species of special concern.
-

The information is important for guiding future management and harvest permitting decisions.

One of our primary research tools is surveys, which we are sending to federal and state forest land managers, to large private land managers (e.g., timber companies) and to moss buyers and distributors. Participation in the survey is purely voluntary, and the survey is designed so that responses can be submitted anonymously. Results from the study will be presented in a report to the USFWS/USGS and in a paper published in a peer-reviewed journal. We will also furnish responses to study participants upon request.

We are writing to you (and other bryologists and botanists in both areas of the country) to see if you have any information that could help our efforts. If you have time to answer any or all of the following questions, it would be much appreciated. (Your participation is, of course, voluntary!) If you don't have time to answer all of the following questions, or don't have answers for some, please feel free to reply only to those that you choose. Replies by e-mail would be fine, as would a reply by US mail, telephone, or FAX (contact information is given below).

If you have any questions about the project, please contact me at (541) 737-1745 (telephone), FAX (541) 737-3573, or by e-mail at muirp@science.oregonstate.edu. If I am not available when you call, please leave a message and I will call back. If you have questions about your

rights as a participant in this research project, please contact the Oregon State University Institutional Review Board (IRB) Coordinator at (541) 737-3473 or by e-mail at IRB@oregonstate.edu.

Thanks for any help that you can provide. I look forward to hearing from you!

Sincerely,

Patricia S. Muir, Professor of Botany and Plant Pathology

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Bryologist/botanist Survey Form: (Actual mailing included the following form on a separate page, with more space left for answers than is shown here.)

To the participant: If you have questions or concerns that are not addressed by the attached cover letter, please contact me at the address below. I appreciate your efforts to respond to this survey. **Partial responses are still valuable, so please return this questionnaire even if it is incomplete**.
Feel free to attach additional information if necessary.

Patricia Muir, Department of Botany and Plant Pathology, Cordley Hall 2082,
Oregon State University, Corvallis, OR 97331-2902 Telephone: (541) 737-1745; FAX: (541) 737-3573; email: muirp@science.oregonstate.edu.

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(1) Are you aware of commercial moss harvesting taking place from forests in your area?

(2) If so, do you have information or insights about how much moss is being removed, from which habitats it is being harvested, or the volume being removed?

(3) Do you believe that the volume of moss being harvested is of concern?

(4) Do you have any information on which taxa are being harvested, and, if so, can you provide us with names?

(5) Are any of the harvested species rare or of special concern, and, if so, which are these?

(6) Can you provide us with contact information for people who might have additional information on the extent or effects of commercial moss harvest in your area, or in other areas of the Pacific Northwest or Appalachians?

(7) Do you know of commercial moss processors, buyers or distributors in your area, and, if so, can you provide us with contact information for them?

(8) Would you be interested in being contacted again for further discussion of this issue or in receiving a copy of our report when this project is completed?

Land Manager Cover Letter:

Dear Sir or Madam:

We are gathering and summarizing information on the commercial harvest of moss from forested lands in the Pacific Northwestern and Appalachian regions of the United States. As you know, moss that is harvested from forests is of growing economic importance, but little is currently known about how much is harvested and what the markets for the material are. By gathering this information, we hope to foster the important economic role of this and other alternative forest products, the sustainability of this harvesting, and help to insure that forests will be managed for commercial uses other than timber harvest, as well as for non-commercial ecosystem attributes. The study is funded by the US Department of Interior's US Geological Survey.

As a land manager who oversees forested lands in the region of interest, I am asking your help in determining how much moss is being harvested and sold from your area. I am also interested in how much of the harvested material is sold within the US and how much is exported beyond our borders. I would appreciate it if you would take a few minutes to respond to the enclosed questionnaire, ideally within the next two weeks, and return it in the envelope provided.

Your responses, together with others, will be combined and used for statistical summaries only. Summarized results will be presented in a report to the US Department of Interior's US Geological Survey (which is funding this project), and, potentially, in a paper intended for publication in a scientific or trade journal. We will also furnish responses to study participants upon request. **Your participation in this study is voluntary and you may refuse to answer any question.** However, please be aware that, due to the diffuse nature of the commercial moss trade, only a small sample of land managers will receive the questionnaire, so your participation is vital to the study. The answers you provide are **strictly confidential** and special precautions have been established to protect the confidentiality of your responses. The number on your questionnaire will be removed once your questionnaire has been returned. We use the number only to contact those who have not returned their questionnaire, so we do not burden those who have responded. Your questionnaire will be destroyed once your responses have been tallied anonymously. There are no foreseeable risks to you as a participant in this project; nor are there any certain direct benefits. However, we hope that results from this study will increase the amount of information available for making future management or business decisions, and your participation is extremely valued.

If you have any questions about the survey or the project, please contact me at (541) 737-1745 (telephone), FAX (541) 737-3573 or by e-mail at muirp@science.oregonstate.edu. If I am not available when you call, please leave a message and I will call back. If you have questions about your rights as a participant in this research project, please contact the Oregon State University Institutional Review Board (IRB) Coordinator at (541) 737-3437 or by e-mail at IRB@oregonstate.edu.

Thank you for your help. We appreciate your cooperation!

Sincerely,

Patricia S. Muir, Professor of Botany and Plant Pathology

****

Land Manager Survey Form: (Actual mailing included the following form on a separate page, with more space left for answers than is shown here.)

To the participant: **If you have questions or concerns that are not addressed by the attached cover letter, please contact me at the address below. I appreciate your efforts to respond to this survey.** Partial responses are still valuable, so please return this questionnaire even if it is incomplete. **Feel free to attach additional information if necessary.**

Patricia Muir, Department of Botany and Plant Pathology, Cordley Hall 2082, Oregon State University, Corvallis, OR 97331-2902 Telephone: (541) 737-1745; FAX: (541) 737-3573; email: muirp@science.oregonstate.edu.

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1. Do you represent a federal, state, or private agency?
   - ☐ federal agency
   - ☐ state agency
   - ☐ private company
   - ☐ other _____

2. If you represent a public agency, please identify the agency and district:
_____

3. Please identify the general region of lands under your management:
   - ☐ Southern Appalachians (TN, NC, SC, AL, GA)
   - ☐ Central Appalachians (WV, VA, KY)
   - ☐ Northern Appalachians (NY, OH, PA)
   - ☐ other _____
   - ☐ Alaska
   - ☐ Washington
   - ☐ Oregon
   - ☐ California

4. Do you allow any moss harvest from these lands for commercial use?
   - ☐ yes
   - ☐ no

5. Have you received any requests for permission to harvest moss for commercial use within the past five years?
   - ☐ yes
   - ☐ no

6. Are permits required for harvesting moss from these lands?
   - ☐ yes
   - ☐ no (if not, skip to question #14)
   - ☐ not applicable

7. If permits are issued, is there a permitting fee?
   - ☐ yes
   - ☐ no
   - ☐ not applicable

8. The cost of the permit is: ☐ a flat rate of _____

   ☐ a fee of _____ per harvest unit _____ (see question #9)

9. How much harvest is allowed under one permit? Our preference is to receive figures in terms of air dry weight. If alternate measurements are used please indicate units, e.g. wet weight, bushels, bales or bags (specify size).

10. Are requests for moss harvest permits ever rejected?
   - ☐ yes
   - ☐ no
   - ☐ not applicable

11. What criteria are used in deciding whether to issue a permit to an individual or a business?

12. What, if any, regulations are harvesters asked to comply with (e.g., removing only epiphytic mosses, removing moss below a specified height only, etc.)?

13. What monitoring procedures, if any, are used to check that harvested quantities meet permit requirements?

14. Do you maintain records on amounts of moss harvested from lands under your jurisdiction?

☐ yes
☐ no
☐ not applicable

15. Can you provide us with information on the number of permits issued and/or quantities harvested (permitted harvest) per year (either in summary or raw form)? Please provide units for this estimate; as above, air-dried weight is preferred. Fill in the information that is available (or provide this type of information in another format, if that is more convenient**).**

Year	no. of units harvested	units	no. of permits issued	value of permits issued
2003				
2002				
2001				
2000				
1999				
1998				
1997				

16. Do you allow moss to be harvested without permits? ☐ yes ☐ no

17. If you do allow harvest without permits, can you estimate the quantity of moss harvested from your lands without permits per year (air dried weight or other units)?

18. If you require that moss harvesting be by permit only, are you aware of moss harvesting occurring on your lands without your permission (that is, illegally)? ☐ yes ☐ no ☐ not applicable

19. If so, can you give an estimate of the quantity of moss that is harvested from your lands illegally?

20. In your opinion, is the moss harvest occurring in your area decreasing, stable, or increasing? Please provide reasons, if you have information or ideas.

21. Do you think present levels of regulation for moss harvesting are ☐ adequate, ☐ inadequate ☐ excessive, or ☐ no opinion?

22. Which taxa of mosses (or liverworts) are most heavily harvested on your lands? Do you have concerns about potential impacts of current harvest levels on any of these species?

23. Do you know any moss buyers, processors, or distributors in your area that we could contact for more information? Please provide contact information for them (fill in any of the following).

name	address	phone	fax	e-mail	website

Business Cover Letter:

Dear Sir or Madam:

We are gathering and summarizing information on the commercial harvest of moss from forested lands in the Pacific Northwestern and Appalachian regions of the United States. As you know, moss that is harvested from forests is of growing economic importance, but little is currently known about how much is harvested and what the markets for the material are. By gathering this information, we hope to foster the important economic role of this and other alternative forest products, the sustainability of this harvesting, and help to insure that forests will be managed for commercial uses other than timber harvest, as well as for non-commercial ecosystem attributes. The study is funded by the US Department of Interior's US Geological Survey.

As someone who is involved with commercial trade of mosses, I am asking your help in determining how much moss is being harvested and sold from your area. I am also interested in how much of the harvested material is sold within the US and how much is exported beyond our borders. I would appreciate it if you would take a few minutes to respond to the enclosed questionnaire, ideally within the next two weeks, and return it in the envelope provided.

Your responses, together with others, will be combined and used for statistical summaries only. Summarized results will be presented in a report to the US Department of Interior's US Geological Survey (which is funding this project), and, potentially, in a paper intended for publication in a scientific or trade journal. We will also furnish responses to study participants upon request. **Your participation in this study is voluntary and you may refuse to answer any question.** However, please be aware that, due to the diffuse nature of the commercial moss trade, only a small sample of people and companies involved in moss buying and selling will receive the questionnaire, so your participation is vital to the study. The answers you provide are **strictly confidential** and special precautions have been established to protect the confidentiality of your responses. The number on your questionnaire will be removed once your questionnaire has been returned. We use the number only to contact those who have not returned their questionnaire, so we do not burden those who have responded. Your questionnaire will be destroyed once your responses have been tallied anonymously. There are no foreseeable risks to you as a participant in this project; nor are there any certain direct benefits. However, we hope that results from this study will increase the amount of information available for making future management or business decisions, and your participation is extremely valued.

If you have any questions about the survey or the project, please contact me at (541) 737-1745 (telephone), FAX (541) 737-3573 or by e-mail at muirp@science.oregonstate.edu. If I am not available when you call, please leave a message and I will call back. If you have questions about your rights as a participant in this research project, please contact the Oregon State University Institutional Review Board (IRB) Coordinator at (541) 737-3437 or by e-mail at IRB@oregonstate.edu.

Thank you for your help. We appreciate your cooperation!

Sincerely,

Patricia S. Muir, Professor of Botany and Plant Pathology

Business Survey form: (Actual mailing included the following form on a separate page, with more space left for answers than is shown here.)

To the participant: **If you have questions or concerns that are not addressed by the attached cover letter, please contact me at the address below. I appreciate your efforts to respond to this survey.** Partial responses are still valuable, so please return this questionnaire even if it is incomplete. **Feel free to attach additional information if necessary.**

Patricia Muir, Department of Botany and Plant Pathology, Cordley Hall 2082, Oregon State University, Corvallis, OR 97331-2902 Telephone: (541) 737-1745; FAX: (541) 737-3573; email: muirp@science.oregonstate.edu.

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1. We have identified your company as one that processes, buys or sells natural mosses that are harvested from forests. To which category or categories does your business belong?
   - ☐ harvester
   - ☐ buys directly from harvesters
   - ☐ buys from other businesses
   - ☐ packager or processor
   - ☐ wholesaler
   - ☐ retailer

2. We are interested in **green or dried forest mosses** only (**not** peat moss, Spanish moss, or lichens). Which moss products do you carry?
   - ☐ green moss
   - ☐ sheet moss
   - ☐ mood moss
   - ☐ other _____
   - ☐ log moss
   - ☐ decorator moss
   - ☐ Oregon moss
   - ☐ other _____

3. We would like to purchase a small sample of each moss product (that is not still attached to wood) that you carry. We will gladly reimburse you for costs of up to $40.00. Please enclose an invoice and mail to us at the Oregon State University address given above. If advance payment is required, please send an invoice and we will provide advance payment.

4. In your opinion, is the demand for moss
   - ☐ decreasing,
   - ☐ stable,
   - ☐ increasing, or
   - ☐ no opinion?

5. In your opinion, is the supply of moss
   - ☐ decreasing,
   - ☐ stable,
   - ☐ increasing, or
   - ☐ no opinion?

6. Do you think present levels of regulation for moss harvesting are
   - ☐ adequate,
   - ☐ inadequate
   - ☐ excessive, or
   - ☐ no opinion?

7. What is the market for the moss that you sell?

8. If you are able to provide contact information for any of your business customers, fill in any of the following.

name	address	phone	fax	e-mail	website

9. Please estimate what percentage of the moss that you deal with is sold to domestic and to foreign markets. Domestic_____% Foreign_____%

10. If some of your moss is exported, what countries are the primary recipients?

11. For each type of moss product that you carry, please answer the following questions:

	Product 1	Product 2	Product 3	Product 4
Name of Product				
From which areas does the source material for each product come? Please estimate percentages.	Alaska ____% Washington____% Oregon ____% California ____% NY, OH, PA ____ WV, VA, KY_____ TN, NC, SC, AL, or GA ____% imported ____% other US source:	Alaska ____% Washington____% Oregon ____% California ____% NY, OH, PA ____ WV, VA, KY_____ TN, NC, SC, AL, or GA ____% imported ____% other US source:	Alaska ____% Washington____% Oregon ____% California ____% NY, OH, PA ____ WV, VA, KY_____ TN, NC, SC, AL, or GA ____% imported ____% other US source:	Alaska ____% Washington____% Oregon ____% California ____% NY, OH, PA ____ WV, VA, KY_____ TN, NC, SC, AL, or GA ____% imported ____% other US source:
How many businesses or harvesters do you purchase from?	____ businesses ____ individuals	____ businesses ____ individuals	____ businesses ____ individuals	____ businesses ____ individuals
Can you provide contact information for any of the businesses from which you purchase moss? (Fill in any of the following: Name, Address, Phone, Fax, E-mail, Website)				
Estimate total quantities purchased or sold in the past year and for the past five years. Please provide units of measurement (e.g. air dried pounds, bushels, etc.).	2003: 2002: 2001: 2000: 1999:	2003: 2002: 2001: 2000: 1999:	2003: 2002: 2001: 2000: 1999:	2003: 2002: 2001: 2000: 1999:

	1998:	1998:	1998:	1998:
Is the material packaged or otherwise modified by your company?	☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no
If modified, how is it processed?				

Feel free to attach additional information, if appropriate, and thank you again.

Appendix 2 – Surveyed Population

(Note: Appendix 2 is not available for public release, as confidentiality of respondents must be protected. Hence Appendix 2 is omitted from this release version. Please contact P.S. Muir if you have questions about the surveyed population and respo ndents that are not addressed in the previous text of this report.)

The following table includes names and addresses for all individuals, agencies and corporations contacted in this study. Asterisks (*) denote contacts who responded to surveys. Information is organized by:

(1) Type of contact:
- "Bryologist" -- includes bryologists, botanists, and other scientists with expertise relevant to the study.
- "Buyer" – includes buyers, suppliers, retailers, and wholesalers involved in the moss trade
- "Manager" – ("LM") – includes land managers of various types;

(2) State within contact type, alphabetically. In some cases, add-on contacts within a particular contact type are at the end of that type's section, not in order by state.

(3) Alphabetically within states within contact types. Land manager contacts are alphabetized by type (AK Dept. of Forestry [ADF], BIA, BLM, Corporation, NPS, State Forest [SF], USFS, WA Dept. of Natural Resources [WDN], Organization [Alliance of Forest Workers and Harvesters, TRAFFIC offices, etc.]).

Appendix 3 -- Moss Samples Procured and Sent out for Species Identifications

Species found in sample numbers shown in **bold** were determined by **J. Peck**, those that are not bold were determined by D. Smith. Some sample numbers are missing or are numbered using an alternative system, owing to timing difficulties associated with our method of obtaining and sending samples out for determinations.

1 – Sweet Home Ranger District, Willamette National Forest, OR confiscated moss, furnished by A. Smith
2 – Sweet Home Ranger District, Willamette National Forest, OR confiscated moss, furnished by A. Smith
3 – Skokomish River Drainage, WA, confiscated moss, furnished by C. Marbet
4 – material around planted bulb pots purchased from Smith & Hawken, Inc, furnished by H. & V. Mccune
6,7 – 100% Natural Sheet Moss (Darice, Inc., Strongsville, OH 44136, bags purchased at Crafts 2000 in Vienna, WV), furnished by D. Rubino
8 – Green moss, bag purchased at Crafts 2000 in Vienna, W VA, furnished by D. Rubino
9 – Sample sent by International Flower Imports -- sold as "Mood Moss"(survey participant 351)
10 – As above, but sold as "Sheet Moss"
11 – Oregon Green Moss (bag packaged by Forest Products Packaging Co., Independence, OR; purchased at Creative Crafts and Frames in Corvallis, OR)
12 – Moss covering soil of a potted African violet purchased in Corvallis, OR
BB1 –Fiberex, Florence AL (contents were wood fiber, excelsior, not moss)
BB2 –Straw Weavers (1 Longfellow Place, Ludington, MI; contents were *Tillandsia sp.*)
BB3 –
BB4 –(Regenboog, 1861 Westoak Pkwy., Marietta, GA; contents were lichens; *Cladonia sp*.)
BB5 –Luster Leaf Products (2220 Techcourt, Woodstock, IL)
20 – Whitney Farms Green Moss (GardenGrow Co., PO Box 100, Independence, OR 97351 – 6.6 liter bag; purchased at Shonnard's in Philomath, OR)
21 – As above, but 13.2 L bag
22 – Moss Cloth Hanging Basket (TropiCare of Oregon, St. Paul, OR 97137; purchased at Flower Land Nursery, Corvallis, OR)
23 – Moss from a bulk bale purchased at Flower Land Nursery, Corvallis, OR
24 – Hiawatha Green Moss (410 cu. in. bag furnished by M. Thompson, Hiawatha Corp., Shelton, WA)
25 – Oregon Ornamental Moss (Moss Mini-bale, purchased at Garland Nursery, Corvallis, OR)
26 – Oregon Green Moss (0.5 pound bag, no company name or city on bag, purchased at Garland Nursery, Corvallis, OR)
27 – Design Accents Moss Bag (Quality Growers, Deleon Springs, FL 32130 – also says "Made in Mexico;" purchased in Lincoln City, OR)
28 – second bag same as #27
29 – Oregon Mountain Green Moss (2.2 liter bag, Forest Products Packaging Co., 5180 Center Street, Salem, OR 97301; purchased in Medford, OR, furnished by M. Wineteer)
30 – Luster Leaf Decorator Moss (200 sq in. bag, Luster Leaf Products, Inc., 2220 Techcourt, Woodstock IL 60098; purchased in Medford OR, furnished by M. Wineteer)
31 – Whitney Farms Green Moss (13.2 liter bag, Rod McLellan Co., PO Box 70, Independence, OR, www.whitneyfarms.com; purchased in Medford, OR, furnished by M. Wineteer)
32 – Schultz All Natural Green Moss (4 qt bag, Schultz Co., PO Box 173, St. Louis, MO 63043-9173; purchased in ME, furnished by C. Kuhns; *species determined by D. Smith because of place of purchase, but sample was PNW material)*
33 – second bag same as #32
34 – Mosser Lee Sheet Moss – (125 sq in bag , Mosser Lee, Millston, WI 54643, www.mosserlee.com; purchased in ME, furnished by C. Kuhns)
35 – Regenboog Natural Beauty Flatmoss (1 oz. Bag, Regenhoog Dried Flowers, Inc. 1861 West Oak Parkway, Marietta, GA; purchased in ME, furnished by C. Kuhns; *species determined by D. Smith because of place of purchase, but sample was PNW material*)
36 – second bag same as #35

37 – Hiawatha Green Moss (410 cu in bag, Hiawatha Corporation, Shelton, WA 98584; purchased in ME, furnished by C. Kuhns)
38 – second bag same as #37
39 – small sample of moss collected from site of recent moss theft (sent by David Richert, Dept. of Conservation & Recreation, Division of Natural Heritage, Commonwealth of Virginia, 252 West Main Street, Suite 3, Abingdon, VA 24210)
40 – Dry shag (purchased from Ho Grown, PO Box 2083, Port Angeles, WA 98362 (360-417-0201))
41 – Fresh shag – same source as #40
42 – Dry curly – " "
43 – Fresh curly -- " "
44 – Dry feather -- " "
45 – Fresh feather -- " "
46 – Fresh assorted -- " "
47 – Sheet moss – bulk (purchased from Quality Moss, 1040 Soshayma Lane, Young Harris, GA 30582; two random subsamples [parts 1 and 2] sent out for species identifications)
48 – Sheet moss – bulk (purchased from Pinehill Natural Moss Supply, PO Box 1971, Oceana, West Virginia 24870; www.pinehillfloralmoss.com; two random subsamples [parts 1 and 2] sent out for species identifications)
49 – Mood moss –bulk – (purchased from Quality Moss as in #47; random subsamples sent out for species identifications)
50 –Bagged moss (6.6 liter bag; GardenGrow Co., PO Box 100, Independence, OR 97351, purchased at Mad River Garden Nursery in Arcata CA; furnished by M. Antoine
51 – Schultz All Natural Green Moss (4 qt bag purchased at WalMart in Wytheville, VA; T. Thomas indicated that Schultz buys from Hiawatha)
52 – Decorator Moss (675 sq in bag purchased at Lowe's Home Improvement Center in Wytheville, VA)
53 – Second bag as in #52
54 – Create a Craft Floral Moss (2 oz. bag purchased at WalMart in Charleston, WV; labeled FloralCraft, Ludington, MI 49431; sent to that company for distribution to WalMart by T. Thomas' company, Appalachian Root and Herb, Rainelle, WV [T.Thomas, pers. comm.)
55 - 58 – duplicates of #54

The following case studies were furnished by D.K. Smith, U TN, who determined species in these and other samples, noted above :

Case Study Bags 32 and 33 of Schultz Natural Green Moss. Schultz Co. St. Louis, MO are of interest because they illustrate the commercial traffic in flora moss is clearly traded across the country. The suite of species is consistent with rich, mesic to moist forests of the Pacific Northwest. The harvest strategies appear to be non-discriminating given the mixture of taxa. Associated species within the specimen bag suggests that the mossy mats are stripped from the lower bole and base of trees. If this is the case, the harvest technique is destructive and recovery as a renewable resource is unlikely.
Case Study Bag 54. Create-A-Craft by FloraCraft, Ludington, MI. This Wal-Mart product contains mixtures of species that are not congruent with associations as they occur in the wild. The mixture of *Hypnum imponens* (log) and *Hypnum fertile* (log) is unlikely from one gathering. The mats of *Thuidium delicatulum* (log or tree base, or sometimes over rock) probably represents a third source. It would appear that the packager, FloralCraft receives large bagged mixtures from the gatherers, which are randomly stuffed into the retail packages to desired weight. These are then wholesaled to Wal-mart where they reach the retail market. Such could be said for some of the other floral packages.

Case Study Bag 58. Create-A-Craft by FloraCraft, Ludington, MI. This Wal-Mart product contains mixtures of species that would not be associated in a single gathering. Most likely this bag represents an assortment of remainders. It looks like it could have been swept off a floor in a processing area. The dominant *Thuidium delicatulum* would typically be a log or humic soil species. The co-associates of *Hypnum curvifolium* and *Hypnum fertile* suggest two separate harvest sites. The presence of *Aulacomnium heterostichum* and scraps of *Leucobryum albidum* point to tree bases or soil substrates. *Trichocolea tomentella* and *Plagiochila porelloides* suggest a site of greater moisture, either damp humus, wet log base, and near water. *Hylocomium brevirostre* is most typical of humic soils and over boulders of northern hardwoods forests

Appendix 4 -- U.S. Exports of mosses, lichens, fresh, dried, etc. otherwise prepared (HTS code 0604100000)

In the following table, "District" refers to the U.S Customs district from which the merchandise departed the U.S. It does not necessarily reflect the origination point for the material (for example, material may originate in OR, but be trucked to NY and shipped out from there). Information provided by U.S. Census Bureau's Trade Data Services.

U.S. EXPORTS OF DOMESTIC AND FOREIGN MERCHANDISE
1998-2003

0604100000 MOSSES, LICHENS FRESH DRIED ETC OTHERWISE PREPARED
(In dollars)

COUNTRY	DISTRICT	1998	1999	2000	2001	2002	2003
DOMESTIC MERCHANDISE:							
CANADA	MAINE	0	0	2,635	0	0	0
CANADA	OGDENSB	23,771	34,961	23,406	4,602	9,194	23,925
CANADA	BUFFALO	88,838	17,062	56,665	85,173	99,664	75,321
CANADA	SEATTLE	14,671	29,792	8,973	21,315	13,554	0
CANADA	GTFALLS	3,383	17,380	0	6,224	13,082	0
CANADA	PEMBINA	0	2,857	6,185	8,817	6,648	18,098
CANADA	DETROIT	331,340	216,874	364,795	275,069	477,699	403,048
CANADA	LV EST	290,679	279,997	220,634	208,918	194,943	176,550
CANADA Total		752,682	598,923	683,293	610,118	814,784	696,942
MEXICO	LAREDO	493,683	349,851	185,852	74,589	221,203	179,010
MEXICO	EL PASO	0	0	0	0	16,065	0
MEXICO	SAN DGO	90,189	54,820	40,833	27,190	106,274	151,178
MEXICO	NOGALES	191,867	661,897	70,792	71,667	80,045	84,858
MEXICO Total		775,739	1,066,568	297,477	173,446	423,587	415,046
GUATMAL	NY CITY	0	0	0	0	52,669	0
GUATMAL	MIAMI	0	269,800	545,900	354,010	39,420	0
GUATMAL Total		0	269,800	545,900	354,010	92,089	0
SALVADR	MIAMI	18,998	0	0	0	14,081	0
SALVADR Total		18,998	0	0	0	14,081	0
HONDURA	PHILA	0	12,070	0	0	0	0
HONDURA	MIAMI	0	0	0	0	0	4,806
HONDURA Total		0	12,070	0	0	0	4,806
NICARAG	MIAMI	0	0	0	0	0	0
NICARAG Total		0	0	0	0	0	0
C RICA	MIAMI	0	0	0	0	0	11,000
C RICA Total		0	0	0	0	0	11,000
BERMUDA	NY CITY	2,697	0	0	0	0	0
BERMUDA	TAMPA	0	0	0	0	0	7,560
BERMUDA Total		2,697	0	0	0	0	7,560
BAHAMAS	TAMPA	0	0	0	0	2,935	3,166
BAHAMAS	MIAMI	0	0	0	11,155	14,150	0
BAHAMAS Total		0	0	0	11,155	17,085	3,166

JAMAICA	MIAMI	0	0	0	5,902	0	0
JAMAICA Total		0	0	0	5,902	0	0
CAYMAN	MIAMI	0	0	0	0	5,707	0
CAYMAN Total		0	0	0	0	5,707	0
HAITI	MIAMI	0	0	2,550	0	0	0
HAITI Total		0	0	2,550	0	0	0
DOM REP	MIAMI	0	56,250	176,044	0	0	4,188
DOM REP Total		0	56,250	176,044	0	0	4,188
ANGLLA	MIAMI	4,830	0	0	0	0	0
ANGLLA Total		4,830	0	0	0	0	0
GRENADA	MIAMI	0	0	0	0	0	2,690
GRENADA Total		0	0	0	0	0	2,690
BARBADO	MIAMI	0	0	5,194	0	0	0
BARBADO Total		0	0	5,194	0	0	0
N ANTIL	LOS ANG	0	0	2,864	0	0	0
N ANTIL	MIAMI	0	0	0	0	18,213	0
N ANTIL Total		0	0	2,864	0	18,213	0
COLOMB	MIAMI	0	0	0	8,836	0	0
COLOMB Total		0	0	0	8,836	0	0
VENEZ	MIAMI	0	0	8,528	0	0	10,170
VENEZ	HOUSTON	0	0	29,430	0	0	0
VENEZ Total		0	0	37,958	0	0	10,170
GUYANA	TAMPA	3,840	0	0	0	0	0
GUYANA Total		3,840	0	0	0	0	0
ECUADOR	NY CITY	6,998	0	0	0	0	0
ECUADOR Total		6,998	0	0	0	0	0
PERU	MIAMI	63,957	0	0	0	0	0
PERU Total		63,957	0	0	0	0	0
FINLAND	PHILA	0	0	0	4,972	0	0
FINLAND Total		0	0	0	4,972	0	0
U KING	NY CITY	19,886	35,251	0	0	0	0
U KING	NORFOLK	0	0	0	0	0	2,709
U KING	LOS ANG	13,104	0	0	0	0	0
U KING	SEATTLE	17,942	14,922	0	0	0	0
U KING	MIAMI	25,492	0	0	0	0	0
U KING Total		76,424	50,173	0	0	0	2,709
NETHLDS	NY CITY	9,150,480	9,951,429	5,022,493	0	0	0
NETHLDS	NORFOLK	149,686	0	171,883	0	0	0
NETHLDS	CHRLSTN	12,034	0	0	49,337	0	0
NETHLDS	SAVANNH	841,785	52,000	147,371	31,388	8,000	30,000
NETHLDS	TAMPA	204,977	488,979	75,223	0	0	0
NETHLDS	MOBILE	25,601	0	0	0	0	0
NETHLDS	SAN FRN	118,340	0	0	0	0	0
NETHLDS	SEATTLE	2,425,929	4,927,186	4,599,673	140,836	0	0
NETHLDS	MINNPLS	8,875	0	0	0	0	0
NETHLDS	MIAMI	0	2,838	0	0	0	0
NETHLDS	HOUSTON	0	0	10,911	0	0	0
NETHLDS Total		12,937,707	15,422,432	10,027,554	221,561	8,000	30,000
BELGIUM	NY CITY	947,724	1,402,626	0	0	0	0
BELGIUM	NORFOLK	95,754	0	0	0	0	0
BELGIUM	LOS ANG	171,878	0	0	0	0	5,539

BELGIUM	CHICAGO	0	0	0	5,800	0	0
BELGIUM Total		1,215,356	1,402,626	0	5,800	0	5,539
FRANCE	NY CITY	41,152	0	0	0	0	0
FRANCE	SEATTLE	0	16,000	0	3,271	0	0
FRANCE Total		41,152	16,000	0	3,271	0	0
FR GERM	BUFFALO	0	15,173	0	0	0	0
FR GERM	NY CITY	93,156	81,205	260,763	0	0	0
FR GERM	NORFOLK	17,500	0	0	0	0	0
FR GERM	CHRLSTN	5,996	0	0	0	0	0
FR GERM	TAMPA	0	3,701	7,281	0	0	0
FR GERM	SEATTLE	350,439	856,078	1,801,073	77,996	16,403	13,806
FR GERM	DETROIT	215,275	56,145	182,197	85,886	116,298	105,545
FR GERM Total		682,366	1,012,302	2,251,314	163,882	132,701	119,351
SWITZLD	NY CITY	22,469	0	0	0	0	0
SWITZLD	SAVANNH	4,079	0	0	0	0	0
SWITZLD	SEATTLE	39,516	40,608	52,386	0	0	0
SWITZLD Total		66,064	40,608	52,386	0	0	0
LATVIA	TAMPA	17,201	0	0	0	0	0
LATVIA Total		17,201	0	0	0	0	0
POLAND	SEATTLE	0	3,064	0	0	0	0
POLAND Total		0	3,064	0	0	0	0
AZERBJN	MIAMI	23,413	0	0	0	0	0
AZERBJN Total		23,413	0	0	0	0	0
SPAIN	MIAMI	18,395	0	0	0	0	0
SPAIN Total		18,395	0	0	0	0	0
ITALY	BUFFALO	0	55,267	0	0	0	0
ITALY	NY CITY	0	0	49,870	24,935	13,020	0
ITALY	NORFOLK	0	0	0	30,710	30,460	56,981
ITALY	LOS ANG	57,393	25,410	0	0	7,519	12,201
ITALY	MILWAUK	0	0	0	0	11,620	0
ITALY	DETROIT	109,731	112,846	147,438	157,880	127,925	89,403
ITALY	HOUSTON	0	0	0	0	0	6,636
ITALY Total		167,124	193,523	197,308	213,525	190,544	165,221
GREECE	MIAMI	3,193	0	0	0	0	0
GREECE Total		3,193	0	0	0	0	0
INDIA	SAVANNH	0	0	0	8,092	0	0
INDIA Total		0	0	0	8,092	0	0
INDNSIA	NY CITY	0	0	0	0	3,630	0
INDNSIA Total		0	0	0	0	3,630	0
CHINA	LOS ANG	31,664	55,377	60,724	73,719	0	0
CHINA Total		31,664	55,377	60,724	73,719	0	0
KOR REP	NY CITY	0	0	0	0	283,104	490,790
KOR REP	LOS ANG	20,700	0	0	0	0	0
KOR REP Total		20,700	0	0	0	283,104	490,790
HG KONG	NY CITY	0	0	0	0	0	2,236,851
HG KONG	LOS ANG	3,600	0	0	0	0	0
HG KONG	SEATTLE	0	8,542	0	0	0	0
HG KONG Total		3,600	8,542	0	0	0	2,236,851
TAIWAN	LOS ANG	0	0	0	0	0	0
TAIWAN	SEATTLE	46,023	51,556	13,277	0	0	0
TAIWAN Total		46,023	51,556	13,277	0	0	0

JAPAN	MAINE	8,250	0	0	0	0	0
JAPAN	NY CITY	0	47,568	0	0	0	0
JAPAN	SAVANNH	12,252	0	7,906	0	0	0
JAPAN	LOS ANG	52,263	19,493	34,945	8,250	17,902	8,250
JAPAN	SAN FRN	111,000	0	0	0	0	0
JAPAN	COL-SNK	77,442	18,353	2,875	0	0	0
JAPAN	SEATTLE	31,270	222,809	213,399	41,989	0	0
JAPAN	ALASKA	0	5,148	0	0	0	0
JAPAN	CHICAGO	26,403	0	0	0	0	0
JAPAN	DALLAS	11,745	0	0	0	0	0
JAPAN Total		330,625	313,371	259,125	50,239	17,902	8,250
AUSTRAL	SEATTLE	12,262	0	0	0	0	0
AUSTRAL Total		12,262	0	0	0	0	0
N ZEAL	COL-SNK	0	0	2,666	0	0	0
N ZEAL Total		0	0	2,666	0	0	0
WORLD TOTAL		17,323,010	20,573,185	14,615,634	1,908,528	2,021,427	4,214,279

Appendix 5 -- Websites that Pertain to NTFP's (including some businesses that sell moss)

Website Address	Notes
Nonprofit and Government Sites that Address NTFP Issues or Provide Quantitative Information Relevant to Moss Harvesting	
http://www.pwcfc.org/news/index.htm#mushrom_report	Pacific West Forestry Center. Documents describing participatory research involving mushroom harvesters and links to a variety of related reports and publications.
http://www.unl.edu/nac/forest-farming.html	USDA National Agroforestry Center. A set of documents related to NTFP cultivation in agroforestry (particularly ginseng, goldenseal, and mushrooms) with related links.
http://www.rainforest-alliance.org/news/archives/news/news44.html	Online report by Rainforest Alliance, "Annotated collection guidelines, standards, and regulations for trade in non-timbe forest products (NTFPs) and botanicals." Includes many rele links, including one to a document that promotes ethical and sustainable use of forest botanicals.
http://agroforestry.net/overstory/overstory53.html	The Overstory Agroforestry ejournal; The Overstory # 53, "Nontimber Forest Procducts: an introduction." Site include examples of NTFPs, their importance, references and relatec links.
http://ifcae.org/ntfp/	Institute for Culture and Ecology, "Nontimber Forest Produ US." Provides information on conservation and managemer of NTFPs for commercial, recreational, and subsistence use Site includes links to a bibliographic, species and links databases, as well as to a variety of related IFCAE reports ar publications.
http://www.sfp.forprod.vt.edu/special_fp.htm	VA Tech. Dept. of Wood Science and Forest Products, USI Forest Service Southern Research Station, and Top of the Ozarks RC & D in Missouri, "Non-Timber Forest Products. Web site devoted to creating a national clearing house for information on NTFps. Includes information on products ar buyers/sellers, as well as publications, fact sheets, tutorials, a relevant links.
http://www.nps.gov/plants/medicinal/pubs/countingcohosh.htm	North Carolina Wildflower Preservation Society XIV #2, 20 "Counting Cohosh." Describes a study to determine sustainable harvest levels for cohosh species and bloodroot, supported by the Medicinal Plant Working Group (www.nps.gov/plants).
http://www.fallsbrookcentre.ca/webmain/programs/Forest/Forest%20Certification/introduction.htm	Falls Brook Centre, "Forest Stewardship Including Nontimb Forest Products." Falls Brook Centre is a sustainable community development and training centre in New Brunswick, Canada that includes NTFPs in its program. Sit has links related to NTFP certification and other matters related to NTFPs.
http://www.nps.gov/plants/medicinal/workinggroup.htm	Medicinal Plant Working Group, "Green Medicine." This group facilitates sustainable use and conservation of medicir plants, particularly in the U.S. It is part of the Plant

	Conservation Alliance (PCA) and serves as the North Amer Plant Specialist Group of IUCN's Species Survival Commission. Site contains links to numerous publications a articles related to NTFPs.
http://www.fs.fed.us/forestmanagement/reports/sold-harvest/index.shtml	USDA Forest Service, "Forest Management – Sold and Har Reports for all Convertible Products." Includes NTFP repo and information links, and gives the value of moss harvest permits sold from the National Forest system as a whole, by year. Includes this information for some, but not all, USFS Regions as well.
http://www/fpl.fs.fed.us/documnts/usda/agib666/aib66609.pdf	USDA Ag. Information Bulletin AIB 666. M.G. Thomas a D.R. Schumann. 1993. "Income Opportunities in Special Forest Products: Self-help Suggestions for Rural Entrepreneurs. Chapter 9. Greenery, Transplants, and Flor Products." Describes a variety of NTFPs, including moss, information about marketing, distribution, labor needs, and resource conservation considerations.
http://www.fs.fed.us/pnw/fight.pdf	von Hagen, B., J.F. Weigand, R. McLain, R. Fight, and H. Christensen. 1996. Conservation and development of nontimber forest products in the Pacific Northwest: An annotated bibliography. USDA Forest Service Gen. Tech. PNW-GTR-375. 246 p.
http://www.fs.fed.us/forestmanagement/reports/sfp/index.shtml	USDA Forest Service, "Forest Management – Reports – Spe Forest Products." Information on a variety of NTFPs harves from National Forest lands in the U.S., including relevant li
http://dataweb.usitc.gov	U.S. International Trade Commission, "USITC Trade Datab Tariff and trade information available by code; includes mos And lichens.
http://www.fs.fed.us/pnw/pubs/gtr585.pdf	Lynch, K.A. and R.J. McClain. 2003. "Access, Labor and V Floral Greens Management in Western Washington's Forest USDA Forest Service General Technical Report PNW-GTR 585. 61 p. Describes changes between 1994 and 2002 in NTFP management in western coastal WA, including rules access and harvester, buyer, and manager perspectives on th rules. Discusses labor and property access issues as necessa components of sustainable forest management strategy, and includes recommendations and a fine bibliography.
http://www.natlforests.org.about_us.html	Home page for the National Forest Foundation, a nonprofit partner of the USFS. Features many community-based fore links.
http://www.edo.or.blm.gov/planning/nepa/siuslaw/ce/CE-04-08.pdf	USDI Bureau of Land Management, "Special Forest Produc Program, Categorical Exclusion Review." Outlines rules and regulations for harvesting NTFP's from Eugene District of I in OR (excludes moss from harvest).
Businesses (additional business addresses in Appendix 2):	
http://www.hohgrown.com/pcat.phtml?cat=2&PHPSESSID=bbb8f01b2fe8c9e7c7e7d4a4c934dd18	Homepage for Hoh Grown, Pt. Angeles, WA, a company th sells a variety of moss products.
http://pinehillfloralmoss.homestead.com	Home page for Pinehill Floral Moss Supply, a company in V

	that sells moss products.
http://hiawathacorp.com/Moss.htm	Home page for Hiawatha, Inc., a company in WA that sells variety of NTFPs, including moss.
http://www.theflowermart.com	Home page for Mirsky Inc., a company in OR that sells mos and other dried botanicals.
http://hawkmountaintrading.com	Home page for Hawk Mountain Trading, a company that bu log moss and other NTFPs
http://www.pinehillfloralmoss.homestead.com/	Home page for PineHill Floral Moss, a WV company that se sheet moss.
http://rolandsofcalifornia.com	Home page for Roland's of California, a company in CA tha sells moss and other NTFPs
http://www.cfg-greens/com/index.html	Home page for Continental Floral Greens, a company based TX that sells moss (purchased, at least in part, from the PNV and other NTFPs.
http://www.oz.net/~evergren/	Home page for Hood Canal Evergreens, a company based in Belfair, WA that sells moss and other NTFPs
http://www.winterwoods.com	Home page for Winter Woods Inc., a company in WI that se moss and other NTFPs