What do we know about commercial moss harvest in the Pacific Northwest?

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It's hard to go anywhere west of the Cascades and not be greeted with a soft blanket of moss draping the trees and ground. It's so ubiquitous we don't even notice it most of the time—except for a few individuals who keep an eye out for those occasional fat mats that drive what has become a multi-million dollar industry in the Pacific Northwest. Based on an estimated international export value of $16 million in 1999, the total harvest of forest moss (mosses and liverworts combined) from the Pacific Northwest may have topped 81.5 million lbs that year alone (air dried)(Muir 2004). There are a lot of things about moss harvest we don't know, but one thing is clear—ignoring it is no longer an option. Long overlooked, the nontimber forest product of forest moss is finally commanding attention.

Why We Care

Forest moss has been a minor, special, or non-timber forest product for over 50 years in this region (e.g., Shaw 1949). A recent survey of Pacific Northwest (PNW) land managers found that 37% of respondents had received requests to commercially harvest moss on their land (Muir 2004). Local and migrant subsistence and commercial harvesters work part- to full-time hiking through the woods to mossy spots, peeling thick pelt-like moss mats off trees and shrubs (and increasingly logs), packing the fresh material into burlap sacks, and trudging it back to buying sheds for a quarter to a half dollar a pound (Peck 1990). The sheds generally air-dry the moss, occasionally tumble it to remove dirt, compress it into ~25 lb bales, and sell to large national and international floral greens wholesalers who sell the moss for $2-3 a pound (Peck 1990, Muir 2004). Modern uses of forest moss include filling for topiary, lining for hanging flower baskets, shipping medium for bulbs, and decorative uses in the global floral trade (von Haggen & Fight 1999).

We didn't pay a lot of attention to moss when timber was king, but the search for alternative income streams focused attention on the nontimber forest product (NTFP) industry as a whole in the 1980's and 1990's. The periodic appearance of articles in the popular literature and government brochures promoting NTFP harvest was followed by studies of the extent and growth potential of the industry (e.g., Schlosser et al. 1992). In addition to what and how, questions also arose about who was involved in this industry (e.g., Love et al. 1992). The rapid growth NTFP commercialization led to the creation of the Northwest Special Forest Products Association, a coalition of "industry firms, government agencies, organizations and individuals interested in the promotion and development" of this industry (NWSFP brochure, 1996).

Most moss harvest has historically taken place on federal lands, which prompted concern over issues of sustainability and rare species (Liegel 1992). Mosses and liverworts play a variety of ecological roles in forest ecosystems, including providing nesting material and food for birds (USDA FS & USDI BLM 1993) and invertebrates (Peck & Moldenke 1999) and storing and cycling minerals and water (Nadkarni 1984). Many mosses and liverworts are most abundant in old-growth and are rarely or never found in young and mature stands (USDA FS & USDI BLM 1993). Traditionally viewed by many agencies as more of a "service to local communities than a revenue source" (Peck 1990), regulation of NTFPs has been slow to develop. Chronic underfunding has further complicated efforts to meet mandates to protect rare species and species diversity (USDA FS & USDI BLM 1994) and to maintain ecosystem function. Some small help may be on the way, however, as a provision on a pilot program included in the 2000 Appropriations Act (HR 2466, sec. 339; under review in 2004) returns a portion of NTFP revenues (which for moss alone totaled over $10,000-25,000/year nationally for USDA FS and USDI BLM between 1997-2003, Muir 2004) to local units (Chamberlain et al. 2002).

Recent revisions of national forest management plans and specialty reports in the PNW include sections dedicated to addressing the management of alternative products, but proposed management guidelines are often developed by armchair experts in the biology, physiology, or ecology of whole groups of organisms, which often

fail to be operational. Case in point: restricting harvest of epiphytic moss to "every other stem" (USDA FS 1995)—allowing harvesters to remove material from 50% of stems on one day, and return the next to remove material from another 50%, and the next for another 50% and so on without violating their permit guidelines.

Regulations also have unanticipated consequences for neighboring landowners: in the first year after the Siuslaw National Forest in northwestern Oregon set a cap on commercial moss harvest on the Hebo District at 110,000 lb per year, harvest on nearby Tillamook BLM land increased from 11,000 lb/yr to over 200,000 lb/yr (F. Duran, pers. comm.), prompting Tillamook BLM to reduce the number of permits they sold the following year. Recent increases in illegal harvest from protected areas such as the Olympic National Park (Hutten 1999) may reflect reductions in either available moss supplies, access to these supplies, or both.

There is also debate over continuing to allow the commercial harvest of moss in Late Successional Reserves, which are to be managed toward old-growth condition (USDI BLM & USDA FS 1997), due our lack of understanding about the impacts of commercial harvest on ecosystem functions. This had led some to call for a prohibition of commercial moss harvest in old-growth forests (e.g., Muir 2004). In fact, we have little information on ecosystem impacts of harvest or even the renewability of the resource (Muir 2004). While modern forest management is able to draw on centuries of silvicultural research, moss harvest has been studied for barely a decade.

What We Know

Much of the research into commercial moss harvest has taken place on the Hebo Ranger District of the Siuslaw National Forest, in the coastal fog belt of northwestern Oregon.

The first project in the summer of 1994 identified 19 mosses, 6 liverworts, 8 lichens, and 2 vascular plants impacted by harvest from understory trees and shrubs (Peck 1997a). Vascular plants and lichens were relatively rare and almost always found only in mats large enough to accumulate soil. Three groups of species were identified: nontarget species generally avoided by harvesters because they are not saleable (vasculars, lichens, and some mosses and liverworts that are not green or are too hard to harvest in abundance); incidentally harvested species taken opportunistically or when growing entwined with more desirable species; and the target species that grow in sufficient abundance to attract harvesters (*Antitrichia curtipendula*, *Eurhynchium oreganum*, *Frullania* sp., *Isothecium myosuroides*, *Neckera douglasii*, *Porella* sp., and *Rhytidiadelphus loreus*). This study found that large mats dominated by the ubiquitous moss *I. myosuroides* were more abundant in older, conifer dominated stands. Limiting commercial moss harvest to these stands could channel harvest toward moss mats with a few, common species—and hopefully away from mats with higher diversity.

These same species, with a handful of additions varying by region, have been found in other studies from western Oregon. More diverse sites have had more sensitive lichen species (Vance & Kirkland 1997), drier sites have had fewer liverworts and lichens (Peck & Muir 2001a), and moister sites have had more moisture-loving log and ground mosses such as *Rhytidiadelphus loreus* (Hutten 1999). A recent study of commercially sold moss (purchased in plastic bags from wholesalers or retailers) found 28 species of moss, 6 liverworts, and trace amounts of 6 lichens (Muir 2004). These purchased samples seem to have originated from throughout the region, and included some valley species not previously known to be commercially harvested (e.g., *Antitrichia californica*), as well as a number of hardy invertebrates (Peck & Moldenke, unpub. data). To date the only moss species of concern found in harvestable moss mats has been the common and abundant old-growth associate *Antitrichia curtipendula*, which was originally listed as a ROD Survey Strategy 4 (USDA FS & USDI BLM. 1994) species but later removed from the list (USDI BLM & USDA FS 2003). However, these studies have all been done on tree and shrub moss; log moss, which is generally prohibited from harvest on public land, may include many more sensitive species.

We continue to know little about what impact harvest has on the development and species composition of moss communities. We do know that what is left behind is not the same as what used to be there; fewer species, with very different relative abundances, remained behind after harvest of understory vine-maple shrubs in the Oregon Cascades (Peck & Muir 2001b), suggesting that different communities grow back from what were harvested. Even after three years, the number of species on those stems was still lower than before harvest

(R.W. Kimmerer 2004 pers. comm.). A similar reduction in the total number of species and the average number of species per sample was found three years after harvest of canopy big-leaf maple limbs in western Washington (Cobb et al. 2001). At least in the short-term, moss harvest does appear to reduce diversity.

When mosses grow back after harvest it is thought that most of the regrowth comes from the bits that are left behind, as well as encroachment from nearby, unharvested areas (Cobb et al. 2001, R.W. Kimmerer 2004 pers. comm.). Diversity may start high, then drop off for a long period of time as the "bully mosses" take over, and increase again after the mats are large enough to develop sufficient soil for more moisture-loving species, including vascular plants, to thrive. Apparently "virgin" moss mats in the Coast Range near Tillamook, OR were overwhelmingly dominated by these bully mosses (Peck 1997c), which are the same as the target species for harvest. The time required for this apparent stabilization, and for the development of soil for greater diversity, is still unknown. However, it may be that harvesting relatively young "second growth" shrub moss on a rotation basis has less of an impact on diversity than harvesting moss mats that span the gamut from young to old.

Early estimates of moss regrowth rates were based on the assumption that the moss mat harvested off a shrub stem could not have taken longer to develop than the shrub stem was old. Dividing the weight of the moss mat by the age of the shrub, then, gave a rough estimate of net periodic accumulation. This accumulation rate has been used to estimate likely recovery times and resulted in recommended rotation periods of 10-15 years for wet sites in the Coast Range near Hebo, OR (Peck & McCune 1998) and of 21-23 years for drier areas in the central western Cascades of Oregon (Peck & Muir 2001b). Recently, however, a study of vine-maple shrub stems showed that larger mats tend to be found on more horizontal stems even though those stems may not always be very old (Ruchty et al. 2001), casting doubt on these early regrowth rate estimates.

Even after a decade, this stem has reaccumulated virtually no moss at all. However, some stems, especially ones with a horizontal aspect, once again have 100% cover on the upper surface.

Better estimates require long-term regrowth studies, but few have been done. Ten years following harvest near Hebo, OR, on average only 50% of the harvested surface area is again covered by moss (unpub. data). No mats are more than 1/3 inch deep, whereas the original moss mats were well over 3 inches deep. The resulting minimum rotation periods are on the order of 15-35 years (averaging 25). Similarly slow growth was seen on those harvested canopy big-leaf maple limbs in Washington; after three years, only 27% of the surface area had been recolonized (Cobb et al. 2001). These slow growth rates contrast with those found when harvestable mosses were grown hung in the forest in mesh nets, increasing in mass over a 13 month period by 11.8% (*Antitrichia curtipendula*) and 3.7% (*Isothecium myosuroides*)(Rosso et al. 2001). Recovery following harvest, however, may require additional time just to get large enough (in volume) to retain enough water to promote such rapid growth (D. Norris pers. comm.).

Even in fairly wet areas, however, the range of moss abundance is tremendous. Ten mossy sites near relatively wet Hebo, OR were estimated to have 107-1310 lb/acre (~140-1700 lb/acre at 30% moisture content, which is typical in the Coast Range at the time of harvest)(Peck & McCune 1998). Drier areas are even more variable; only 29% of sites on the western slope of the Cascades in western Oregon had any moss at all, and harvestable quantities of moss (>110 lb/ha) were only found in six sites (143-478 lb/acre, or ~165-550 lb/acre at 15% moisture content, which is typical in the Cascades at the time of harvest). Harvestable moss in these areas is only expected to be found in stands less than 1640' in elevation and in areas less than 164' from perennial water (Peck & Muir 2001a). Riparian areas tend to have faster growth and recovery than upland areas (Peck & McCune 1998), but harvest in riparian areas may be incompatible with special riparian forest guidelines aimed to protect rare species communities and preserve hydrologic function.

The presence and abundance of harvestable moss is also dependent upon the presence and density of suitable host species. The predominant host for commercially harvestable moss in western Oregon and Washington has repeatedly been found to be vine maple (Peck 1997b, Vance & Kirkland 1997, Hutten 1999,

Peck & Muir 2001a). The tendency for some other host species (e.g., elderberry) to support more diverse moss communities suggests that restricting commercial harvest to only vine maple could reduce the overall impacts of harvest on the epiphytic bryophyte community. Alternatively, forest management to promote the presence of understory hardwood shrubs and trees could also mitigate moss harvest impacts (Peck & McCune 1998). The retention of hardwood trees and shrubs provides critical habitat for mosses, liverworts, and lichens (Hazell & Gustafsson 1999), including species that are commercially harvested. Silvicultural practices that retain these hardwood and shrub species would serve to promote biodiversity, including of the vertebrate and invertebrate populations associated with moss, as well as provide for a future commercial moss resource (Vance et al. 2001, Muir et al. 2002). For instance, longer rotations would enable more vine maple to reach a horizontal condition, which apparently favors the development of larger moss mats (Ruchty et al. 2001), thus promoting moss abundance.

What We Can Do

Given that moss farming techniques are just beginning to be developed (e.g., Nadkarni 2004), demand for moss from the National Forests and other publicly and privately owned forest land is not expected to decline in the near future. While there is no clear trend in the demand for commercially harvested forest moss (Muir 2004), pressure to manage this NTFP continues to rise. Sustainable strategies for the commercial harvest of moss will reduce pressure on our parks and preserves, facilitate community-based industries, and ensure long-term economic and ecologic stability.

Unfortunately, the wildcard in sustainable management is widespread illegal harvest. Despite increased regulation of the legal harvest including maximum weight restrictions, businesses generally report that moss supplies are stable (Muir 2004). This confirms the suspicions of PNW land managers; 41% of respondents recently indicated that illegal harvest occurs on their lands (Muir 2004). Recent estimates of the total national moss harvest, in fact, were many times the reported legally permitted harvest on publicly owned lands, which are the predominant source for forest moss (Muir 2004). Illegal harvest also often involves log and riparian habitats, increasing the likelihood of impacting species of concern. The illegal harvest of log mosses may also have a disproportional impact on landscape level diversity, as heavily decayed logs are important habitat for a large number of mosses and liverworts (Rambo 2001). Strategies to control illegal harvest will be required regardless of other management recommendations and may ultimately be the most important factor in sustainable management.

Many of the unknowns above will require more study, and more work is underway to address some of these issues. In the meantime, however, some general recommendations regarding commercial moss harvest can be drawn from what we have learned so far.

- All forest lands scheduled for timber harvest should be permitted for commercial moss harvest immediately prior to felling. A tremendous amount of natural resources are lost each year when harvest operations do not allow for nontimber forest product extraction; resources for which landowners receive no income. Even if moss harvesters underreported their harvest, the result would still be a net gain for the landowner. Further, these are the only areas when moss harvest impacts are known to be negligible. Private landowners can obtain contact information for potential harvesters from nearby federal agencies that issue similar permits.
- Forest lands in the northern Coast Range managed primarily for timber production (e.g., matrix on federal lands, USDI BLM & USDA FS 1997) and open for commercial moss harvest should be assessed for their moss resource inventory. Without these data, it is impossible to evaluate the sustainability of allowable harvest quantities. At the very least, it should be recognized that commercially harvestable quantities of forest moss are unlikely to occur above 1500', at any great distance (>100-150') from a source of at least seasonal humidity, under young (< 50 yr old) conifer overstories, or in stands lacking hardwood trees or shrubs. A quick scan of GIS layers should reveal what proportion of any given district remains as potential moss harvest areas.

- Forest lands in the northern Coast Range managed primarily for timber production and open for commercial moss harvest should be assessed for regrowth rates in order to determine rotation periods. Moist, foggy coastal areas may expect rotation periods on the order of 10-20 years, while drier inland areas can expect to require 20-30 years.
- Only personal use harvest should be allowed in areas with low natural levels of moss inventory. A general moss harvest program in areas with low moss inventories would incur costs that would exceed permit revenues (particularly when enforcement is taken into consideration) and the ecological impacts of moss harvest in these areas would likely outweigh the benefit to the few members of the public interested in commercial harvest. This may include much of the Cascade Range and the southern half of the Coast Range.

Specific to harvest on federal lands:

- Due to the prevalence of illegal harvest, districts should be divided into moss harvest zones on the basis of road access to facilitate law enforcement patrol. Rotating these zones would allow sufficient time for regrowth. For instance, a district of 100,000 ha divided into fifths (with about 10,000 ha of mossy areas in each zone) with a known moss inventory of 1000 kg/ha in mossy areas and a known regrowth rate of 25 kg/ha/year could permit harvest of 100 kg/year and rotate zones every 5 years (thus allowing 20 years of "fallow" time for recovery before being opened for harvest again).
- Commercial moss harvest should be prohibited in areas designated as Late Successional Reserves (USDI BLM & USDA FS 1997) or areas otherwise managed toward old-growth condition. Harvest impacts on hydrology, nutrient cycling, moss, liverwort, and lichen diversity, and invertebrate communities are likely inconsistent with the development of old-growth ecosystem functions. Such areas should also be protected from harvest to enable future studies to evaluate these impacts.
- Periodic surveys of the species impacted by harvest should be conducted to ensure that harvest practices have not shifted to more sensitive species.
- Truly operational guidelines for harvest should be developed. For instance, the specific area open for harvest should be marked on a permit map, not simply where the vehicle must be parked. Permits should be issued in increments of 50 lbs, regardless of water content, and buyers required to retain each permit upon sale. Harvest should be restricted to only trees and shrubs less than 20' off the ground and more than 150' (paced, not slope corrected) from perennial water. No tools of any kind (rakes, machetes) should be allowed in the vehicle or on site.
- Local law enforcement should be given the right to stop and check all ntfp permits at any time and should be informed of the areas on a district not open for legal harvest at any given time. Most poachers on Forest Service lands simply wait until law enforcement officers have retired for the afternoon/evening before hauling out their illegal harvest.

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