

Timber Harvesting Plan for the Blackwater Pine Mushroom Management Area

Prepared for

**Small Business Forest Enterprise Program
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Executive Summary

This report describes the logic and methods for timber harvesting in the Blackwater Pine Mushroom Management Area, an 867-ha forest in the Squamish Forest District. The report was developed with reference to current published, anecdotal, and observed growth characteristics of the fungi.

The pine mushroom (*Tricholoma magnivelare*, or Canadian *matsutake*) is ectomycorrhizal and exists in a symbiotic relationship with living forest trees. The fungal hyphae gather nutrients released by the breakdown of organic material and pass the nutrients to trees in return for photosynthate sugars.

Because litterfall is observed to be inadequate for robust pine mushroom growth, the report suggests that woody root systems will better supply nourishment for mushroom production. The report focuses on the development and release of woody root systems.

In the 867-ha Blackwater Pine Mushroom Management Area, the expected short-term benefits of implementing this mushroom management plan are an estimated \$1.08 million government stumpage revenue and \$2.75 million employment creation in timber harvesting and wood products manufacturing. Incremental pine mushroom production is estimated at \$1.52 million over a 20-year period, at which time a second timber harvest entry might occur.

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Timber Harvesting Plan for the Blackwater Pine Mushroom Management Area

1.0 Introduction

The objective of this project is to describe locations and methods for harvesting timber in the Blackwater Pine Mushroom Management Area. Timber harvesting should have high regard for pine mushroom (*Tricholoma magnivelare*, or Canadian *matsutake*) values, and seek to enhance mushroom production, or at least minimize the likelihood of damage.

Pine mushrooms are ectomycorrhizal fungi and require living tree hosts. The fungi will re-establish following catastrophic disturbances such as fire or clearcutting. However, in this area, fruiting body production will not begin again for approximately 60 years following the disturbance. This plan therefore recommends timber harvesting using only selection silvicultural systems.

This timber harvesting and pine mushroom enhancement plan was developed with limited current knowledge of pine mushroom biology. Much of this report is based on professional judgement and critical observation, rather than on sound proven scientific knowledge. In implementing this plan, managers should be aware of its experimental nature. Monitoring is essential. Different harvesting techniques that provide a range of site disturbance effects are deliberately recommended to offer a wide range of reference points for future forest managers.

1.1 Site Description and History

The Blackwater Pine Mushroom Management Area (BPMMA) is located northeast of Pemberton in the Squamish Forest District (Figure 1). Access to the area is by public road which also provides access to private residences and the Birkenhead Lake Provincial Park. The area is in the mountainous "transition zone" between coastal and interior climatic influences. The area is mainly within the CWHds1 biogeoclimatic unit, with some lower elevation area in the IDFww1 unit, and higher elevation area in the CWHms1 unit.

Pine mushrooms have been collected from the area for the past 50 years. Japanese workers at a sawmill operating in D'Arcy in the 1940s introduced the native and non-native communities to the mushroom. Collection for personal consumption (fresh, dried, or canned) has continued since then. Commercial harvesting for export to the Japanese market began in 1978. Revenues to commercial pickers in recent years are estimated at \$100 000 to \$300 000 annually.

In 1992, the BPMMA was designated by map notation, with authority from the district manager. Local residents and representatives from the University of British Columbia and the B.C. Forest Service were involved in meetings leading to this designation. Such a designation provided for a five-year period in which no clearcutting was to occur, and any timber removal would use selection silvicultural harvesting systems. No timber has been harvested in the area since 1992.

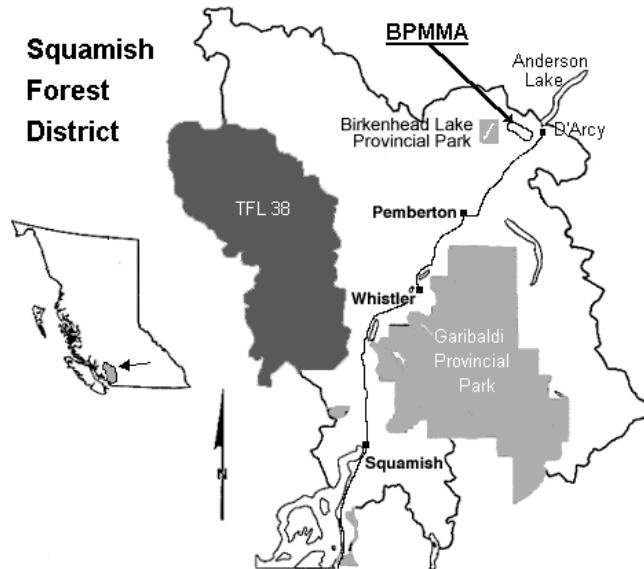


FIGURE 1. Key map to the Blackwater Pine Mushroom Management Area (BPMMA)

The BPMMA is a northeast-facing slope covering 867 ha (roughly 6 by 1.5 km) of Crown forest land. The northerly aspect ensures that soil moisture is maintained on site longer than in surrounding areas. The forests in the BPMMA are largely fire-origin, with two main fire events (estimated to have occurred in the years 1795 and 1862) originating present stands. The 1795 fire regenerated all but a few isolated patches of forest, while the more recent fire (136 years ago) appears to have killed all the trees in some stands, and left the thick-barked Douglas-fir (*Pseudotsuga menziesii*) living in other stands. Accordingly, present timber stands are generally either 135 year old and even-aged, or two-tier, with dominant older Douglas-fir and a second layer of shade-tolerant hemlock (*Tsuga heterophylla*), cedar (*Thuja plicata*) and some western white pine (*Pinus monticola*) and Douglas-fir.

In addition, the lower slopes of the BPMMA have a history of harvesting dating from the 1940s through the 1960s. Approximate locations of historic harvesting activity are shown on Map C in Appendix IV. The harvesting used a diameter-limit selection system and ground-based equipment. The large, older Douglas-fir (estimated at 70-90 cm dbh and 35-40 m height, based on observations of stumps and remaining trees) were removed, releasing an understorey of advance (mainly hemlock) regeneration.

The BPMMA is a coastal-interior transition area, with unique climatic influence. Summer temperatures may be sustained near 40° C in early August, and plentiful autumn rains fall most years. The area might be termed pine junction; four species of pine grow in the neighbourhood: white pine occurs throughout the BPMMA, yellow pine (*Pinus ponderosa*) grows a few kilometres to the east, lodgepole pine (*Pinus contorta*) grows in regenerating disturbed areas, and whitebark pine (*Pinus albicaulis*) grows at the uppermost forested elevations.

2.0 Pine Mushroom Management

The BPMMA yields from 2 to 8 metric tonnes of pine mushrooms annually, with variations mainly due to annual temperature and moisture regimes (Shirley Pietila, pers. comm.). Fruiting bodies occur in the 600-1400 m elevation band, although most collection activity is concentrated in areas below 1100 m. Certain forest stands in the area produce bumper crops of pine mushrooms, while other stands produce few or none. An attempt was made to characterize the stand attributes associated with prolific production.

2.1 Habitat characteristics

In August 1998, the researchers (Gerrard Olivotto and Randy Marchand) met with long-time local mushroom pickers, who volunteered information regarding the location of productive mushroom patches, and on two different occasions accompanied the researchers for walks through productive patches. Most of the lower slopes were diameter-limit harvested (largest trees removed) 30-60 years ago. The most productive mushroom areas appear to be those previously harvested stands. Productive patches also occur in the natural origin, unlogged stands on the mid-slopes; however these patches are limited mainly to exposed ridges, where the canopy is open. Logged and unlogged samples both occur in the CWHds1 biogeoclimatic variant. Based on discussions with local pickers, we estimate that approximately 15% of the unlogged surface area, compared with 70% of the previously harvested surface area, is pine mushroom producing patch within the BPMMA.

Why are the previously harvested areas producing more mushrooms? Pine mushrooms are ectomycorrhizal fungi which form a symbiotic relationship with living forest trees and depend on those trees for a supply of photosynthate sugars. Current scientific understanding is that the fungal mycelia act as a feeding extension for the root system of the host tree. The fungal hyphae attach to the trees' roots and extend the root system through the soil. The fungus gathers nutrients and moisture for the tree, and is rewarded with sugars that the tree has manufactured from sunlight.

The main nutrient source for the ectomycorrhizae appears to be decomposing organic material. Tree litterfall and coarse woody debris are principally decomposed by saprophytic fungi, and the products of primary decomposition are then gathered and passed to the tree by the ectomycorrhizal fungi.

Although the pine mushroom does not reportedly have the ability to directly access the complex organic compounds in woody material, it appeared during the reconnaissance to be accelerating decomposition. The pine mushroom may form a nutrient sink in the soil environment, removing the products of other soil processes and thereby accelerating those processes. Producing pine mushrooms patches had relatively thin F and H (humus) soil layers, compared with non-producing local areas. Typically, the humus layer was less than 0.2 cm thick in a producing patch, compared with up to 5 cm thick elsewhere. Thin humus was often accompanied by a significant ashy layer (Ae horizon).

We also observed that the best producing mushroom patches were commonly found near the large stumps of Douglas-fir, logged 30-60 years ago. Fruiting bodies occur in an ovoid radius, 5 m upslope to 15 m downslope from the stumps. These old stumps and their remaining root systems may be a reliable source of moisture and therefore attractive habitat for the fungus. However, given our understanding of the needs and role of the organism, it is hypothesized that the pine mushrooms are finding in the dead root systems a long-

term source of gradual nutrient release. The pine mushroom is using the components of the decaying root system to supply nutrients to the regenerating stand.

In the natural, unlogged forest, productive mushroom patches are associated with relatively open canopies. These stands generally have large downed trees, which are the reason for the open canopy. The dead and fallen trees have left coarse woody root systems in the soil. The hypothesis previously mentioned also applies to natural stands. The primary source of organic material from which the pine mushroom sources nutrients to feed to the remaining trees is the root systems of trees that have died. Even-aged stands in the BPMMA, with high timber volumes and low mortality, do not produce commercial quantities of pine mushrooms.

In the previously harvested areas, some trees were felled and left, either because they were too heavy to be yarded with the machines used, or because the butt section contained heart rot. These logs do not support pine mushrooms yet, although older downed logs (with full ground contact, red decaying wood and moss on the surface) *do* appear to be associated with pine mushroom production.

One productive pine mushroom stand (2.4 ha) identified on the maps in Appendix IV for future mycological investigation, was observed in an area with no apparent organic food source other than litterfall. Stumps and fallen logs are both absent. The large Douglas-fir have crowned off, and are growing slowly, with radial increment of 25 rings/cm. The hemlock understorey forms a closed canopy, half the height of the dominant fir, and also grows very slowly. Where insufficient coarse organic material is available, the pine mushroom may be a net drain on both tree layers. This observation correlates with reports from other researchers, that pine mushroom production is often associated with nutrient poor sites and poor rates of tree growth.

2.2 Management for Pine Mushroom Habitat

The previous observations suggest that a preferred habitat for pine mushrooms in the BPMMA would be a thrifty stand of younger trees growing among a plentiful supply of dead coarse woody root material. This plan proposes that forest managers apply the following tenets for mushroom management:

1. Maintain shade on the forest floor to protect the living mycelia. Research trials at Date Creek (Kispiox Forest District) and at Roberts Creek (Sunshine Coast Forest District) indicate that canopy openings larger than 20 m by 30 m are detrimental to all species of ectomycorrhizal fungi, including pine mushrooms.
2. Maintain adequate stocking of living trees in an early to mid-seral stage. These trees will act as ongoing hosts for the fungi. Living trees in the better-producing patches in the BPMMA presently range in size from 10 cm diameter at breast height (dbh) and 6 m tall to 25 cm dbh and 18 m tall.
3. Ensure a continuous supply of dead coarse tree roots. Pine mushrooms appear to prefer roots of Douglas-fir and white pine, although this observation may coincide with natural historic conditions in the BPMMA. Stands should be managed to maintain some mid-sized trees, which will provide future large root systems when presently released roots have been consumed.
4. Favour regeneration of western white pine. Observations here, and in other pine mushroom producing areas, indicate that the presence of recently dead pine trees reliably indicates mushroom habitat. Although white pine is susceptible to blister rust, it will grow to 25 cm dbh, and in some cases to over 60

cm dbh in the BPMMA, before dying. Resistant seed from Texada Island might be used for regeneration to ensure survival and development of large root systems.

Enhancement of pine mushroom production in the BPMMA will best be accomplished by selective removal of large overstorey trees. This strategy will provide the mycelia with a supply of decomposing roots, and increase the vigor (and need for food) of the residual trees.

The nutrients that the mushroom derives from dead root systems are eventually consumed. Although aggregate production from the BPMMA has not increased or decreased over the past 20 years of commercial harvesting, certain previously harvested stands do not produce mushrooms. One area, selectively harvested in 1952, originated entirely from the 1862 fire, and did not have the larger 1795-origin Douglas-fir present. The stumps indicate that smaller trees, ranging from 35 to 45 cm dbh, were removed. This area no longer prolifically produces pine mushrooms. It also appears that in stands with the larger (80 cm dbh) stumps, pine mushroom productivity is now greater in areas harvested 30 years ago than in areas harvested 50 years ago.

These observations, and the range of existing conditions in the BPMMA, suggest that the forest manager can calibrate and schedule production of nutrients for the pine mushroom. A preliminary estimate is that favourable local growing conditions for Douglas-fir will produce root systems adequate for a 25-year mushroom food supply by approximately 100 years of age, and a 50-year food supply by approximately 150 years of age.

The nutrients released by harvest might be consumed by many different organisms; however, local pickers are confident that the pine mushroom is present "everywhere" on this particular mountainside.

2.3 Implementation Example

To maximize pine mushroom production timber harvest scheduling should maintain a substantial supply of buried dead organic material. Periodic, partial overstorey removal will ensure this supply. For sustainable, *even-flow* mushroom production, enough mid-size trees should be maintained to provide a fresh supply of dead root material, scheduled for release when the current supplies are depleted in 25-50 years. To maximize *short-term* mushroom production, most of the standing large timber volume would be removed, maintaining only enough advance regeneration to shade the forest floor and maintain the ectomycorrhizal association.

Following is an example estimate of volumes to remove and selection harvesting re-entry periods to achieve long-term, even-flow mushroom production and high short-term timber production. Local growing conditions support a mean annual increment of 4-6 m³/ha/yr. White pine, Douglas-fir, and hemlock show favourable growth response to overstorey removal. Existing timber stands are fully stocked, generally 135 years old, and carry approximately 550-650 live m³/ha. Dominant trees are 40-60 cm dbh, and 30-35 m tall. A first entry might remove 50% of standing volume (300 m³/ha). Mushrooms should flourish with the released food supply. Understorey establishment would be encouraged. A second entry in 20 years could remove half the remaining large trees (200 m³/ha), leaving larger stumps and root systems. The stand would then be permitted to recover and produce mushrooms for the subsequent 50 years. A third entry at year 70 would remove some of the remaining large veterans, and some of the smaller (now large) trees released in the first

entry (250 m³/ha). Individual stand dynamics may be planned once detailed cruise information is available, using stand and stock tables from the cruise, a stand density management diagram as described by Farnden (1996), and the Prognosis BC or TASS tree growth simulators.

Establishment of shade-intolerant white pine and Douglas-fir is also desirable for long-term mushroom production, and may require the creation of small openings or corridors. Planting may also be necessary to ensure these species are established.

The pine mushroom management system proposed here differs from that practiced in Japan. In the Japanese method, organic litter is removed from the forest floor (Hosford et al. 1997) and vegetation is thinned to keep it sparse. The Japanese management objective is a soil environment exposed to a greater range of energy and water fluxes, which stimulate more fine conifer roots close to the soil surface and available for mycorrhizal formation (Weigand 1998). The focus is on creating a most favorable environment for the fungi to draw photosynthates from living trees. Japanese matsutake forests experienced dramatic declines in production 20 years after adopting these practices.

The method proposed for the BPMMA instead *increases* the supply of dead organic material available on site, while protecting the forest floor from desiccation. Rather than expecting forest trees to freely support the mushrooms, the notion proposed here is to let the mushrooms earn their keep by also nourishing the trees. The focus here is on accelerating the rate of nutrient cycling within the stand, and maintaining mid-seral (ages 60-120) stand characteristics. This may also result in better rates of tree growth.

3.0 Timber Harvesting

Maps B and C in Appendix IV show the location of the merchantable timber and the proposed harvesting units in the BPMMA. This section discusses specific considerations, with reference to Map C.

3.1 Access

Existing roads provide access up the mountain at both the east and west ends of the BPMMA. Roads proposed in this plan are generally low gradient, cutting across the slope from existing access rather than gaining elevation

The plan on the attached maps proposes construction of six road segments totaling 4.15 km. Of this, 250 m cross class 5 terrain (on a rocky bench verified on site) and 1200 m cross class 4 terrain. Road location and design will require geotechnical expertise. An additional 900 m of road across class 4 terrain, required to access Blocks A1, A2, A3, C6 and C7, is sketched on the map as "potential road", subject to field verification for both stability and adverse hauling grade. The new proposed roads are expected to become permanent access structures, and although closed to vehicle traffic after harvesting, are not expected to be rehabilitated to productive forest land.

These road measurements do not include access to the small horse logging blocks at the lower slope of the BPMMA. Horse logging access routes are expected to be low impact, and to be rehabilitated to productive forest and pine mushroom area after harvesting is completed.

Harvest units are designed to minimize within-block road requirements. Spur roads, which may be required for several of the "G" blocks, should be rehabilitated after harvesting. The scientific literature is inconclusive regarding the effects that disturbance of the forest floor may have on pine mushroom production, other factors being equal. Hosford et al. (1997) report experiments underway to determine effects of site disturbance by pickers (i.e., raking of the duff), however, conclusive results are not yet available. The experiments designed by Weigand (1998) mimic small-scale natural disturbance, but are not designed to investigate site disturbance per se. In the BPMMA, large caterpillar tractors were used in the 1960s logging, while smaller machines were used in the 1940s and 1950s (judging by road gradients and large logs left in awkward yarding positions). Plenty of mushrooms grow in some areas harvested by these machines. It is inconclusive at this time whether, and to what degree, site disturbance is detrimental or necessary for natural tree regeneration and enhanced mushroom production.

The eastern blocks are accessed by way of a road built to service a BC Tel signal repeater located above the BPMMA. This road has grades over 20%, and is only suitable for log hauling after prolonged dry weather. Also, pumice deposits occur throughout the BPMMA. Pumice in the roadbed requires special attention to water control and drainage structures.

3.2 Forest Inventory

The existing forest inventory adequately describes local timber conditions for strategic planning purposes. Forest stands are mainly leading Douglas-fir, with hemlock as the usual second component. Balsam (*Abies amabilis* or *Abies lasiocarpa*) and Sitka spruce (*Picea sitchensis*) occur in the higher elevations of the

BPMMA, and cedar forms a significant stand component at lower elevations. White pine and lodgepole pine both occur in the forest inventory labels. Most stands have at least three tree species, with each species comprising greater than 10% volume component.

The reconnaissance survey found that the existing inventory is inadequate for operational planning and identification of harvest units. The time available for the reconnaissance did not permit development of a new, accurate forest inventory. For this project, the forest inventory was re-interpreted from 1993 aerial photography to identify merchantable stands and historic logging areas, as shown on Maps B and C in Appendix IV.

TABLE 1. Summary of area by merchantability class in the BPMMA

Merchantability class		Gross area (ha)
0	Unmerchantable	114.3
1	Small	357.7
2	Reasonable	137.9
3	Prime	257.4
Total area		867.4

The merchantability classes are defined relative to local conditions in the BPMMA, rather than on an absolute provincial scale. Proposed harvesting area mostly coincides with MC 3, although harvesting with ground-based equipment is proposed for some MC 2 area.

3.3 Crown Closure

During the field reconnaissance, a spherical densiometer (Lemmon 1956) was used to estimate overstorey crown closure, to provide a standard instrument measurement that could be used in subsequent operational timber felling. As reported by others (Vales and Bunnell 1988; Ganey and Block 1994), the instrument was time consuming and subjective, being inconsistent between users, although consistent for a single user once trained to the instrument. Ocular estimates are quicker and generally accurate to within 5%.

Crown closure was found to be an inadequate variable for specifying felling intensities for pine mushroom management. Crown closure is a measure of two-dimensional surface area coverage, while canopy considerations include a depth component, and are three dimensional. A deeper canopy may be more open, and yet have similar outcomes for pine mushroom growth and yield.

3.4 Proposed Harvest Units

The Forest Practices Code establishes a 40-ha maximum size for clearcut openings in this area. A non-clearcut harvest is defined as one which leaves at least 40% of original stand basal area. To maximize short-term pine mushroom production, >80% of stand basal area might be removed where a well-developed understorey exists. However, heavy removals would limit the scale of stand conversion proposed in this

plan, where a large contiguous area is proposed for harvesting. Percentage volume removal is also restricted by other concerns, such as maintaining suitable habitat for spotted owls, maintaining shade on the forest floor, and providing an intermediate ectomycorrhizal host while an understorey develops in some stands.

This plan differentiates between ground-based and cable harvesting systems by slope classes, with a cutoff of approximately 30%. In the ground-based terrain, machines might be used in the larger contiguous "G" blocks, and horse logging might be considered in the isolated 1-6 ha "H" blocks along Blackwater Creek.

3.4.1 Western end: Cable and ground harvesting systems

An all-weather access road is presently under construction up the mountain through the western end of the BPMMA. The 7.5 km of new road is required to access two blocks already approved for harvesting in the years 2000 and 2002. The new road climbs through terrain averaging 15 - 40% slopes, avoids all class 4 and 5 terrain stability, and was designed with a maximum grade of 12%. The western harvesting units are located to maximize use of the new road location.

Units G1-G5

Ground machine (skidder) blocks G1, G2, G3, G4, and G5 are all adjacent to the new road. Ground slopes are 25-35% in these units. The timber consists generally of 135-year-old even-aged stands of Douglas-fir and hemlock, with scattered Douglas-fir veterans (to over 100 cm dbh) and spruce and cedar on wetter sites. Stocking is variable in unit G1, which contains some younger patches with only 200-350 m³/ha. Unit G2 has 500-600 m³/ha, and the other G units presently carry high levels of stocking (> 700 m³/ha). Individual trees are 35-50 cm dbh, with dominant heights of 32-34 metres. Some sections of this timber are naturally thinning — up to one-third of the standing volume has recently blown down, leaving well-spaced, but scarred, residual trees. Harvesting should remove some of the recent windfall in addition to freshly felled timber.

It may be appropriate to take a lighter first entry in these stands, removing 35% of the volume rather than 50%. This approach would encourage development of an understorey layer, while maintaining a windfirm stand and a shaded forest floor. First-entry harvesting would resemble a commercial thinning entry, and leave a significant Douglas-fir component.

Timber removed from units G1-G5 should provide the greatest financial return of all the units proposed in this plan. These units have easy access, the timber features consistent, superior quality, and the proposed harvest method is the most economical. Most of the forest in these units does not presently produce pine mushrooms, and so risk of crop damage is minor. The site disturbance caused by skidders dragging logs should be dispersed, rather than compacting specific trails. Harvesting might imitate the earlier harvesting at the lower reaches of the BPMMA, except that greater stocking will be left and less soil disturbance will occur.

These stands presently have little, if any, regeneration layer. An objective of the harvesting should be to encourage the development of an understorey, thus facilitating a second entry in 20 years. The second entry removal will depend, for both pine mushroom and owl habitat reasons, on the successful establishment of an understorey following first-entry harvesting.

Units C1-C4

Harvest units C1, C2, C3, and C4 are proposed for cable selection harvesting systems. The terrain is steeper in these units (30-65%). The units are designed for uphill yarding through narrow corridors (4 m cleared width), perpendicular to the slope. It is proposed that cable yarding be conducted using a swing yarder to avoid the need for landings and to minimize site disturbance. Units C1 and C2 are designed to permit tailhold locations on roadways, where a large caterpillar machine or cables attached to buried deadmen will reduce rigging expense. Units C3 and C4, which do not have roads at the lower ends, will require tailholds rigged by tying back a network of trees.

Designing cable harvesting blocks requires a tradeoff between yarding distance and rigging cost. Present technology finds an optimal distance at between 150 and 400 m corridor length. The C blocks are laid out within this range.

Timber volumes in these units generally range from 600 to 750 m³/ha, and tree heights in the 35-37 m range. Some portions have a well-developed understorey, and could therefore support greater percentage volume removals than the G units.

Units C1, C3, and C4 largely coincide with mapped class 4 terrain stability. The proposed access roads are located on benches in the topographic data. However, in the woods, the benches appear disjointed, and road location may involve cut and end haul. A geotechnical assessment is recommended.

3.4.2 Central BPMMA: Lower elevations

Units H1-H7

These units are small, ranging from 1 to 6 hectares in size. Although possibly not of large commercial interest, these units may provide a significant income opportunity for enterprising local individuals and are identified accordingly. Some of these stands reportedly produce chanterelle mushrooms, an edible ectomycorrhizal species characteristically found in younger forests than pine mushroom habitat.

Unit H3 was previously harvested in 1951. It is now stocked with mainly Douglas-fir and cedar, 40-55 cm dbh and up to 39 m tall. The present trees are larger diameter than the stumps left from the earlier logging, and the stand is ready for another harvest entry.

Units H4-H6 are located on a raised, dry plateau. The forest is mostly pure Douglas-fir, with smaller log sizes than the lower H units. Unit H5 had a significant lodgepole pine component, which was killed by bark beetles approximately 25 years ago and has since blown down. All the upland H units presently produce pine mushrooms.

The H units are relatively flat terrain (5-10% slopes) and lie near to the Blackwater Road. Access across Blackwater Creek is required. Low-impact harvesting with horses, and light equipment forwarding over temporary bridging across the creek to a staging area on the Blackwater Road, may be feasible procedures that respect environmental sensitivity. Access will pass through pine mushroom producing ground and should be established with local consultation. An additional area of previously harvested stands (up to 40 ha) in the general vicinity might be considered for another harvesting pass at this time.

3.4.3 Eastern end: Aerial and cable systems

The eastern end units are accessed by a steep road (grades to 24%) built to reach a BCTel repeater station located above tree line. In the summer of 1998, log hauling was successfully conducted on the road from a block beyond the BPMMA. However, the road is unlikely to be serviceable in wet weather and therefore the eastern units would be scheduled for summer harvest.

Units A1-A4

These units are recommended for aerial harvesting using helicopter logging, because potential road access appears to have high risk of site disturbance and potential landslide initiation. Only unit A4 is scheduled for harvesting in the near term of this plan, since the present market for logs may not support the higher costs associated with aerial harvesting systems. Flight distances to units A1-A3 depend on how much access can be constructed beyond unit C8. Unit A4 may be merchantable in present markets, with a flight distance of 200-500 m.

Helicopter logging is feasible for single tree selection harvesting, where the residual overstorey is open enough to lift logs clear without entanglement in standing tree crowns. The ground crew can direct the pilot into position using two-way radio communication. The Workers' Compensation Board requires that unstable trees in the harvest unit be felled, so that helicopter rotorwash will not expose workers to undue risk. This requirement would apply mainly to clumps of trees infected with root rot. The stands in the proposed A units are reasonably open now, with 50-60% crown closure. Trees appear firmly rooted, with live crowns 30-60% of the tree height. Stand volumes are 500-650 m³/ha, with diameters to 60 cm.

Single tree selection harvesting sometimes requires use of larger helicopters capable of dead lifting the weight, rather than using a flyway. Production is also slower with dead lift. Slower production and equipment that is more expensive add to costs. The timber in the proposed A units can likely be harvested with a standard 5-tonne class machine, if the larger butt logs are bucked short or ripped lengthwise to reduce weight and maintain value.

Units C5-C8

Units C7 and C8 are accessible via roads that may be built on existing benches, which were verified during the reconnaissance survey. Further professional verification is required to locate the potential road access to above units C6 and C5. If road access is not feasible, some of the timber in C6 might be yarded up during the harvesting in C7. Unit C8 has good deflection for operation of a cable yarding system. Unit C7 is steep, averaging over 60% slope. Both units will require tailhold rigging in standing timber. The timber in these units is similar to that in the A units, with relatively large piece sizes and a high proportion of Douglas-fir.

Table 2 summarizes area and volume estimates for the proposed harvesting units. Volumes are estimated at 35% removal in the G units, and 50% removal from the other units. Growth is estimated at 100 m³/ha during the following 20 years (5 m³/ha/yr), followed by a 50% removal of the accumulated future volume in a second entry. These units would then rest from timber harvesting and produce pine mushrooms for the following 40-50 years, while other units in the BPMMA are selection harvested.

TABLE 2. Summary of areas and volumes in proposed harvest units in the BPMMA

Map Label	System	Timing	Area (ha)	Total Volume (m ³)	1st Volume (m ³)	2nd Volume (m ³)
A1	Aerial	Later	20.19	12 113	6 057	3 634
A2	Aerial	Later	7.00	4 202	2 101	1 261
A3	Aerial	Later	6.27	3 763	1 882	1 129
A4	Aerial	Now	8.83	5 299	2 650	1 590
Subtotal A			42.30	25 378	12 689	7 613
C1	Cable	Now	16.99	11 042	5 521	3 313
C2	Cable	Now	8.04	5 227	2 613	1 568
C3	Cable	Now	14.70	9 552	4 776	2 866
C4	Cable	Now	14.63	9 508	4 754	2 852
C5	Cable	Later	16.78	10 908	5 454	3 272
C6	Cable	Later	9.53	6 196	3 098	1 859
C7	Cable	Now	8.56	5 562	2 781	1 669
C8	Cable	Now	16.63	10 809	5 404	3 243
Subtotal C			105.85	68 803	34 402	20 641
G1	Skidder	Now	10.96	5 479	1 918	1 726
G2	Skidder	Now	6.05	4 237	1 483	1 335
G3	Skidder	Now	11.53	8 647	3 026	2 724
G4	Skidder	Now	9.70	5 820	2 037	1 833
G5	Skidder	Now	7.23	4 696	1 644	1 479
Subtotal G			45.47	29 553	10 343	9 309
H1	Horse	Now	2.54	1 272	636	382
H2	Horse	Now	1.15	575	288	173
H3	Horse	Now	3.71	1 857	929	557
H4	Horse	Now	5.89	3 531	1 766	1 059
H5	Horse	Now	3.90	1 951	975	585
H6	Horse	Now	1.38	690	345	207
Subtotal H			18.58	8 359	4 179	2 508
Total Now			152.41	94 910	43 022	28 916
Total Later ^a			48.42	30 369	15 184	9 111
Total Plan			212.19	132 093	61 614	40 071

^a The "Later" designation identifies units expected to require higher market values for timber than present to justify more expensive access and yarding costs. Volume estimates are based on preliminary reconnaissance information.

3.5 Operational Considerations

Individual stand prescriptions can be developed as part of the Stand Management Prescription (SMP) after detailed surveys of the standing inventory have been made. In general:

1. Maintain a forest canopy. Where openings are necessary, limit opening size to 15X20 m.
2. Cut the largest trees, leaving scattered large trees required for spotted owl habitat.
3. Specify which trees to leave or remove based on stand and stock table analysis in the SMP. An example prescription for one stand might be: cut 75% of stems over 50 cm dbh, cut 35% of stems in the 30-50 cm class, and retain all trees less than 20 cm dbh. Retain all Douglas-fir and white pine less than 40 cm dbh (subject to snags, topography, tree groupings, and safety).
4. Cedar is prone to sun-scald following overstorey removal in this area. Cedar does not form ectomycorrhizal associations, and is not a desirable species for pine mushroom management.
5. Consider forest health risks, especially blowdown, when selecting leave trees.
6. When bucking and limbing, cut tops and slash to ground contact to speed decomposition and absorption into the moss and the mycorrhizal zone. This will also clear access for mushroom pickers. The slash left by the 1960s harvesting makes access in that area dangerous and difficult.
7. As with all selection harvesting systems, avoid May-June, when bark on residual trees will most easily be damaged. Also avoid hauling in October when the Blackwater Road is busy with pickers' vehicles.

4.0 Other Resource Concerns

4.1 Spotted Owl Management

The western two-thirds of the BPMMA coincide with a Special Resource Management Zone for Northern Spotted Owl (*Strix occidentalis caurina*) (SRMZ 18, Birkenhead, Activity Centre E). This activity centre is at the northern limit of the owl's habitat range identified in the Spotted Owl Management Plan (SOMIT, 1997).

Habitat management for the spotted owl aims to create or maintain suitable nesting and roosting locations, and enhance food supplies. The primary food species for the owl is the northern flying squirrel. Ectomycorrhizal fungi are an important food source for flying squirrels, and therefore fungi production is an integral component of a spotted owl management plan. The intent of this plan is to enhance the production of ectomycorrhizal fungi, which will have long term benefit for owls.

Preferred owl habitat includes 50% crown closure, two or more canopy layers, branch retention to within 3 m of the ground, a diversity of conifer tree species in the stand, and at least 20% component of Douglas-fir. Present guidelines for superior owl habitat would maintain at least 200 large trees (> 30 cm dbh) per hectare, several of which have dead and broken tops. At least 5 large snags per hectare should be maintained, and the supply of coarse woody debris in various stages of decay should be maintained above 100 m³/ha in pieces > 30 centimeters dbh.

Our reconnaissance plots indicate that the stands proposed for selection harvesting contain live tree volumes of 500-700 m³. Standing snag volumes are 50-150 m³/ha. Presently 280-530 stems per hectare are greater than 30 cm dbh. Fallers will be able to maintain 200 large trees per hectare if the 35-50% volume removal focuses on the largest stems in the stands.

The forests in the BPMMA are relatively young, fire-origin stands and do not have many large trees with dead tops. Root rot is creating a supply of snags, but these soon topple and become coarse woody debris. Other damaging agents are just beginning to naturally create old growth structural characteristics, and transform the forest into more suitable owl habitat.

The operational guidelines component of the Spotted Owl Management Plan (SOMIT, 1997) describes Type A (superior quality) and Type B (moderate quality) spotted owl habitats. The harvesting proposed in this plan would enhance the selected BPMMA stands from Type B toward Type A habitat quality. Enhancement would continue over time, as present single-layer stands are opened to establish and/or release an understorey and develop structural diversity. A second harvest entry 20 years later will provide additional opportunity for developing long-term structural attributes.

Presently, the best owl habitat in the BPMMA occurs in the system of ridges down slope from, and to the east of, proposed Block C3. The largest Douglas-fir in this area are 100 cm dbh and 40 m tall. Arboreal lichen presence, an important habitat indicator and food source for the flying squirrel, scores 3 and 4 on the scale of 0 to 5. The ridges provide a matrix of alternating open and closed forest. This area, identified on Map C as Core Spotted Owl Habitat (56.8 ha), is not scheduled for harvest in the present plan.

4.2 Riparian Management

The BPMMA drains into Blackwater Creek, a tributary of Gates River. Water from the BPMMA flows via Anderson Lake and Seton Lake to join the Fraser River at Lilloet. Blackwater Creek is a class S3 stream, requiring a 20-m reserve zone and a 20-m management zone. All proposed blocks are outside these zones. The larger blocks proposed in this plan are accessible on existing roads that do not cross Blackwater Creek. Only the small blocks proposed for horse logging require access across the creek.

Miners Creek is a tributary of Blackwater Creek, running in the gully bisecting the BPMMA. The gully is mainly class 5 terrain stability, and furbearer habitat. No harvesting is proposed in the gully. Horse logging blocks on flat ground at the lower end should respect the integrity of Miners Creek.

The BPMMA is not in a community watershed.

4.3 Visual Resource Management

The BPMMA has been assigned a recommended visual quality objective of Modification in the Forest Recreation Inventory. This objective would permit a maximum of 7.1 to 18% recently clearcut area in perspective view, using current Forest Service visual management guidelines. No clearcuts are proposed in the BPMMA.

Selection harvesting, with 50% volume removal, will achieve Partial Retention—a more stringent objective—with 90% confidence, in forests up to 35 m tall. The harvesting proposed in this plan is therefore not constrained by visual management recommendations presently in place for the BPMMA. With high volume retention, harvesting is expected to be mostly unnoticeable. Visible impact to a viewer directly perpendicular

to the slope will mainly occur in the cable yarding corridors. Oblique views of the corridors will be screened by the remaining trees on either side.

Riparian management requirements to maintain trees along Blackwater Creek will also maintain screening between operations in the BPMMA and travelers on Blackwater Road.

4.4 Forest Health

Root rot (*Phellinus weirii*) centres occur throughout the BPMMA, as they do throughout many Douglas-fir stands in the Squamish Forest District. Typically, groups of three to six trees are dead or dying, and cedar regeneration is often present. The bark of dead trees sometimes shows attack by the Douglas-fir bark beetle (*Dendroctonus pseudotsugae*). The reconnaissance survey indicated that root rot incidence is low (< 2% of area). Identified root rot centres should be monitored as part of the Stand Management Prescription for selection harvested areas. White pine, which is resistant to phellinus, might be regenerated in these areas.

Several (three+) species of conk are evident in the BPMMA. A seral transition appears to be underway on some lower slopes, particularly on drier ridges, with conk killing Douglas-fir in an uphill progression and coincident uphill progression of cedar regeneration. Our observations in pine mushroom stands farther north in British Columbia (Nass-Terrace area) suggest that once conk enters a stand, pine mushroom production declines. The hypothesis is that the conk intercepts the photosynthate sugars before the sugars reach the tree roots and become available to ectomycorrhizal fungi. The cedar-conk association should be monitored.

Hemlock looper, a defoliating insect, was observed during the reconnaissance. The insect itself was seen twice, although no defoliation was evident. Hemlock looper is considered to be an endemic resident.

Blister rust has killed most of the white pine trees in the BPMMA, although large healthy individual trees remain scattered (one per hectare) throughout the area, producing cones measuring up to 34 cm long and 9 cm across. An alternate host for the blister rust, black gooseberry (*ribes lacustre*) also occurs throughout the BPMMA. As mentioned earlier, establishment of white pine is an objective for long-term management of pine mushrooms, and trees from resistant seed might be planted.

Risk of blowdown of the residual stands is a concern in selection management. The BPMMA has numerous areas of blowdown, usually associated with root rot, and sometimes (e.g., in Block G1) associated with natural succession in an overstocked stand. Significant blowdown also occurs in higher elevation balsam stands. However, no areas were located in the BPMMA where a stand had been flattened by wind, either recently or in the past. Selection harvesting areas in this plan are not located adjacent to clearcuts, and abrupt boundaries will only occur along road edges. To minimize blowdown risk, rights-of-way should be cleared only to a width required for safety and access of single-lane traffic.

Scars on residual trees are a concern in selection management. Old logging scars provided a means of estimating harvest dates for previously harvested areas. Operations should avoid May-June, when trees are actively growing new cambium and the bark is loose.

5.0 Yield Estimates

Table 2 lists area and volume summaries for the harvest units proposed in this plan. First-entry volumes from accessible blocks are estimated at 43 000 m³. An additional 15 000 m³ is available from aerial and eastern difficult access blocks. Second-entry volumes, available in approximately 20 years, will total another 40 000 m³ if all proposed blocks are accessed.

Pine mushroom yields are estimated using numbers presented in Section 2. A "shiro" is a cluster of mushrooms growing in association with one particular living tree, and a "patch" is a collection of shiros. In northern British Columbia (Terrace-Nass area), a patch is an area producing enough mushrooms to warrant several kilometres hiking through rough terrain, and may be from 5 to 40 ha. The BPMMA is an easily accessible area, with high-density coverage of patch.

Areas logged in the past total approximately 120 ha, and are estimated to be 70% productive patch. Pickers search through approximately another 400 ha in the BPMMA, where an estimated 15% of the area is patch. The total productive patch, therefore, is $(0.7 \times 120 + 0.15 \times 400) = 144$ ha. Average observed annual production from the BPMMA is 4000 kg, or 28 (4000/144) kg/ha of patch.

First entry, accessible harvesting, is expected to convert 152 ha from 15% patch habitat conditions to 70% patch conditions, by creating a plentiful food supply for the pine mushrooms to trade with trees for photosynthate sugars. The net increase in productive area of patch in the BPMMA would be $(0.7 \times 152 - 0.15 \times 152) = 83.6$ ha. Average pine mushroom yields from the BPMMA are expected to increase by $(83.6 \times 28) = 2,340$ kg/yr.

Value estimates are more difficult to derive, since prices for both timber and mushrooms are determined outside the local economy. Present log prices approximate \$25/m³ stumpage value to the Small Business Forest Enterprise Program. Prices for pine mushrooms at the local buying station average \$15/lb (\$33/kg). Pine mushroom prices in 1998 ranged from \$5 to \$75/lb for number 1 and 2 grades. The higher prices occur toward the end of the B.C. harvesting season, when the BPMMA is producing.

At prices of \$25/m³ and \$33/kg, the short-term expected benefits of implementing this harvesting plan would be \$1.08 million government stumpage revenue, and an increased 20-year pine mushroom yield with a value of \$1.54 million. Additionally, logging, sawmilling and value-added use of the harvested timber would create an estimated 86 person-years of employment (\$2.75 million at \$32 000 per job). These estimates exclude timber volumes identified for "Later" in Table 2 (see section 3.4.3).

Other benefits would include the enhancement of spotted owl habitat, and the establishment of a range of trials for later reference. A second harvest of timber from the same harvest units is scheduled for 20 years hence.

6.0 Recommendations for Further Work

6.1 Timber Management

The next steps in implementing this harvesting plan would be the verification of access potential, and detailed assessment of the attributes of the stands to be harvested.

Access

A geotechnical professional needs to specify methods of road construction necessary to provide access across class 4 terrain for proposed road segments in both the eastern and western operating areas. In the eastern area, physical risks should be assessed and the costs of access construction should be estimated before greater investments in timber measurements are made. Although the volume and value of timber in the east are significant, much of the timber may be more expensive to extract than present markets warrant. Access to the proposed horse logging blocks will need to be assessed in consultation with the Ministry of Environment, Lands and Parks, due to the necessity of crossing Blackwater Creek, a class 3 stream.

Timber quality

A detailed cruise of the western blocks, and Blocks C7 and C8 in the east, would describe live and dead tree volumes, with particular attention to the small and mid-sized understorey trees. Radial increment data should be collected for sample trees. This information is needed for growth modelling, an important step in developing stand management prescriptions.

In forestry, the costs of data collection and the value of the data for the purpose at hand always involve a tradeoff. A sample of the cruise card used for our reconnaissance survey is attached as Appendix II.

Harvest profile selection

Once the cruise data are assembled, modelling should be undertaken to determine how desired future stand conditions, in transition from present stand structures, might be achieved. This modelling would form the basis for a Stand Management Prescription, with clear instructions for fallers of cut/leave ratios, by diameter class.

Forest inventory

The present forest inventory for the BPMMA is inadequate for detailed planning purposes. For this project, new photo interpretation was undertaken to identify harvest candidate areas. Future planning for long-term management of the entire BPMMA will require a new inventory database. Again, cost of data collection should be weighed against the value of the information.

6.2 Mushroom Management

Visitors

The BPMMA is accessible on paved roads from Vancouver. One-way travel time is 2.5 hours.

Several types of participants harvest pine mushrooms in the BPMMA. Commercial harvesters sell their pick for cash. The mushrooms are exported, mainly to Japan and increasingly to California and other affluent destinations. The local community also engages in subsistence harvesting, and uses the crop for dried,

pickled, and fresh home consumption. Recreational pickers, often of Japanese ancestry and commuting from Vancouver, also regularly visit the BPMMA.

The Forest Service should anticipate increasing interest in the BPMMA. The shape of the mountain is conducive to wandering by people unfamiliar with forests. If anyone is lost, they can simply walk down hill and will arrive on the Blackwater Road, which runs along the entire base of the slope. Improved signage on the Blackwater Road might help people leaving the woods find the correct direction to their parked vehicle.

Research

Forest Service mycologists, with UBC graduate students, have already established research plots in the BPMMA. More research trials are expected. By facilitating these efforts the Forest Service will gain valuable insights about beneficial and pathogenic fungal influences in the forest ecosystem. A local weather station might be established in the BPMMA, to collect records over the next 20 years.

Local community

Many people in the local communities are keenly interested in pine mushroom production and collection. It may be beneficial to facilitate creation of a supportive interest group. The group might include representatives from the local native and non-native communities, the Forest Service district office, and the Japanese cultural community, as well as a mycologist. This group could monitor the weather station and mushroom production, develop maps and picker access, and coordinate the research trials.

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Appendix II. Survey Cruise Card

Blackwater Pine Mushroom Management Area

Field Survey - August 1998

Date: _____

Strip # _____ Plot # _____ Forest cover label _____

Prism BAF _____ Crown closure _____%

Topography				Plant cover				Growing conditions			
Elevation	Aspect	Slope %	Position	Regen %	Shrubs %	Herbs %	Mosses %	BEC zone	Subzone	Nutrient	Moisture

Soil depth (cm) to bottom of layer							Relative abundance (0-5)				
L	F	H	Ah	Ae	B	C	Snags	CWD	Lichen	Root rot	Mycelium

Species _____ Age _____ DBH _____ BA _____ SPH _____ Height _____ Volume _____

.....

Tree Record: tally all standing trees (dead or alive) in plot greater than 12.5 cm dbh

Tree No.	Species	DBH (cm)	Height (m)	Top diam	Age (yrs)	Live Crown %	Crown class	Lichen load	Pathological remarks
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									

Tree number	Bottom shot	Top shot	Horizontal distance	Calculated height

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