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SECTION A: INTRODUCTION

Pine mushroom harvesting in northwestern B.C. is a growing economic activity, but it is unregulated and poorly documented, so is often in conflict with industrial forestry. This mushroom project, undertaken with the financial support of Forest Renewal B.C., has provided additional information on the distribution and habitat requirements of pine mushrooms in the Skeena-Bulkley Region and helped foster cooperation among forest stakeholders. The research consisted of several components: ecological habitat description; timber/mushroom supply modelling; and comparisons of mushroom habitat and forest development plans. The research plan was the result of a problem analysis and pilot mapping study conducted in March, 1998, and a stakeholders meeting held June 8th, 1998, in Terrace, B.C.

The harvesting of wild forest mushrooms in British Columbia is a significant commercial activity, with estimated yearly revenues of $10 - $40 million dollars, depending on year to year variation in weather and market conditions. Yet mushroom harvesting is totally unregulated, is often in conflict with industrial forest harvesting, and depends primarily on one species, the pine mushroom or matsutake (*Tricholoma magnivelare*).

A literature review and problem analysis undertaken by the Northwest Institute in early 1998 cited five research priorities which should be addressed if mushroom biology and the socio-economics of mushroom harvesting are to become well enough understood that they can be managed in a sustainable fashion in the Skeena-Bulkley Region:

1. Better characterization of pine mushroom habitat and distribution; Mapping of productive mushroom locations and identification of suitable habitat so that forest development planning and silvicultural prescriptions can protect the mushroom resource;
2. Examining the effects of alternative silvicultural practices on mushrooms;
3. Socio-economic analysis of the mushroom industry in the Skeena-Bulkley Region, to accurately determine the employment and revenue levels associated with local mushroom harvesting and to address the need for licensing and monitoring; and
4. Development of a more diversified mushroom sector, looking at the potential for species other than pine mushroom.

A follow-up stakeholders meeting, held in Terrace, B.C., on June 8, 1998, was attended by 25 participants representing mushroom pickers, buyers, First Nations, consulting foresters, the timber industry, researchers and the Ministry of Forests. The consensus at this meeting was that research was needed in these same broad areas, with the following to be emphasized:

1. Better inventory and mapping of the pine mushroom resource;
2. Determining ways to reduce conflicts with industrial forestry, through better planning, community-based co-management, and understanding the long-term impacts of logging; and
3. Exploring the potential for commercial utilization of other mushroom species.

This project directs some preliminary research activities to address the first two of these priorities. While only one year in duration, it sets the stage for further work.

SUMMARY

The first component of the project was undertaken by researchers Rick Trowbridge and Anne Macadam, assisted by technical advisor Marty Kranabetter Ministry of Forests Research. Twenty-one sites known to be highly productive pine mushroom (*Tricholoma magnivelare*) habitat were ecologically described and classified. Sites in the ICHmc1, ICHmc2, and CWHws1 biogeoclimatic units, mainly in the Hazelton, Kispiox, Terrace, and Cranberry-Meziadin areas, were located with the assistance of experienced mushroom pickers, and information on site and stand characteristics, vegetation, and soils was collected at each.

The sites were found to have much in common with pine mushroom habitat described in previous studies elsewhere in B.C. Soil moisture regimes were drier than average and soil nutrient regimes in most cases were poorer than average for the biogeoclimatic subzone and variant due to a combination of soil and site features. Soils were well to very rapidly drained, and generally coarse in texture, often with a high coarse fragment content. Forest floors tended to be relatively thin and classified as hemimors. Plant communities typically featured sparse herb and shrub layers, which often included the species: black huckleberry (*Vaccinium membranaceum*), falsebox (*Paxistima myrsinites*), false azalea (*Menziesia ferruginea*), prince's-pine (*Chimaphila umbellata*), twinflower

(*Linnaea borealis*), bunchberry (*Cornus canadensis*), and rattlesnake plantain (*Goodyera oblongifolia*). Western hemlock (*Tsuga heterophylla*) was consistently the dominant tree species, and lodgepole pine (*Pinus contorta*) was frequently, though not always, present in the tree layer. In most, but not all plots, there was a high coverage of mosses, usually dominated by step-moss (*Hylocomium splendens*) and red-stemmed feathermoss (*Pleurozeum shreberi*). In the ICHmc1 and -mc2 variants, all sites were classified as the 01b Hw - Step moss site series, submesic phase, and in the CWHws1, as the 03a and 03b HwPl - Feathermoss site series, glaciofluvial and typic phases. The ecosystems are described and classified in their report, which begins on page C-1.

The second phase of the project involved a computer model to investigate the synergies and tradeoffs between forest management predominantly for timber, compared with forest management for both pine mushrooms and timber. This work was undertaken by Gerard Olivotto and he found that significant rates of timber harvest are necessary to maximize pine mushroom production.

Mushrooms thrive in younger mature forest, and harvesting of older forest creates a stream of young maturing stands. With continued timber harvesting, the long-term pine mushroom production potential in the Cranberry TSA is two to three times current production levels.

An economic assessment found that the total economic yield from the forest is maximized at a rotation age of approximately 145 years. This rotation age extends the period of mushroom productivity and the development of valuable timber piece sizes. Shorter rotations lose more mushroom value than the gain in wood fibre. Longer rotations lose more timber increment than the gain in mushroom yield. The report identifies further information requirements for mushroom and timber management, and concludes with a comprehensive list of activities that would improve understanding of the subject. That report begins on page D-1.

The third component of the project was a case study to estimate the extent of pine mushroom habitat and the possible extent of conflict with development plans. Five year development plans for the Kispiox small business tenure were used in this case study. The first two years of the development plan had silviculture prescriptions (SPs) prepared, which detailed soil conditions and site series in each block. The 01b site series was identified in the prescriptions but not mapped out. The last three years of the development plan were located on maps but no site descriptions had been prepared. For these blocks, we used air photos to identify and quantify the area under 01b site series. Two categories were used depending on the degree of confidence in the photo interpretation (1 where well–defined, 2 for marginal).

Both methods (SPs and airphotos) determined that the 01b site series occurred in 15% of the proposed cutblocks and almost 30% of the proposed cutblocks in the ICH. In years 3 to 5, the real extent of the 01b in the ICH zone was approximately 4%, or 6.8% if the marginal 01b is included as well. For years 3 to 5 in the development plan, which includes forest zones not expected to have commercial harvests of pine mushrooms, the extent of 01b ranges from 2.25% (1 only) to 3.84% (1 and 2) of the proposed cutblock area. That reports begins on page E-1.

The final phase of the project involved organizing another workshop bringing together the same forest stakeholders (mushroom pickers, buyers, First Nations, consulting foresters, the timber industry, researchers, and the Ministry of Forests), who had met initially in June 1998, in order that we could report on the findings of our research and get input on priorities for further mushroom research.

Pat Moss
Executive Director
Northwest Institute

SECTION B: MAP

SECTION C. ECOLOGICAL DESCRIPTION AND CLASSIFICATION OF HIGHLY PRODUCTIVE PINE MUSHROOM SITES IN NORTHWESTERN BRITISH COLUMBIA

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METHODS

Site selection

Experienced mushroom pickers based in northwest B.C. were enlisted to direct us to sites known to be highly productive pine mushroom habitat. Samples were distributed over three biogeoclimatic units (ICHmc1[1], ICHmc2, and CWHws1[2]), and over as wide a range of landforms and site characteristics as possible. Most of the areas identified were considered "community ground", and well known among local mushroom pickers.

Ecosystem descriptions

Standard procedures, as described in the *Field Manual for Describing Terrestrial Ecosystems* (1998) were used to describe site characteristics, vegetation, and soils for each plot. Data were recorded on FS 882 forms.

All plant species were listed by stratum with estimates of their percent cover. The combined percent cover for each stratum was also recorded. Plant names correspond to those used by Pojar and MacKinnon (1994) and MacKinnon *et al.* (1992). Plots were surveyed for the presence of pine mushroom fruiting bodies. Soil pits were excavated to a depth of at least 60 cm and descriptions of the humus form and mineral soil profile were recorded. Photographs (35mm slides) were taken of the site and soil profile.

Site series were classified based on *A Field Guide to Site Identification and Interpretation for the Prince Rupert Forest Region* (Banner *et al.* 1993). Landforms, soil pedons, and humus forms were classified according to the *Terrain Classification System for British Columbia* (Howes and Kenk

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[1] The ICHmc is the moist cold subzone of the Interior Cedar Hemlock Zone. The -mc1 is the Nass variant, and the -mc2 is the Hazelton variant (Banner *et al.* 1994)

[2] The CWHws1 is the wet submaritime subzone of the Coastal Western Hemlock Zone, submontane variant (Banner *et al.* 1994)

1997), *The Canadian System of Soil Classification* (Soil Classification Working Group 1998), and *Towards a Taxonomic Classification of Humus Forms* (Green *et al.* 1993) respectively.

Stand characterization

A cruise plot was done at each site to determine stand characteristics. A full prism sweep was made at plot centre, usually with a prism BAF of 7, and the diameter at breast height (DBH), height and health codes were noted for each ‘in’ tree. One co-dominant tree was cored at breast height (1.4 m) to determine its age. If the stand was mixed, at least one tree per species was aged. A 'count plot' was also taken approximately 20 m from plot centre in each cardinal direction. In a count plot, the prism sweep was used to count ‘in’ trees, but DBH and height were not measured.

Cruise data was compiled for each site using the MOF cruise compilation program. Tree rings were counted under a dissecting microscope to determine stand age. Site indices were calculated based on tree age and height using MOF Site Tool (version 3.2B).

RESULTS

Study area

A map showing the location of sample plots is included at the beginning of the report. Samples were broadly distributed from the Suskwa River to areas north and west of Hazelton, between Cranberry Junction and Meziadin Lake, in the Terrace area, and north and east of Terrace.

Ecological classification and site attributes

Ecological classification and attributes of the study plots are summarized in Table 1. More detailed information is given in Appendix 1. Plots were well distributed across the area studied (see map). While pine mushroom habitat extends into other ecosystems, the attributes summarized in Table 1 reflect what our guides believe to be the most representative of highly productive sites in northwestern British Columbia. The submesic phase of the 01 Hw - Step moss site series (01b) was identified in all sample plots in the ICHmc1 and -mc2 variants. In the CWHws1, phases of the 03 HwPl - feathermoss site series, which are edaphically similar to the IHCmc/01b, were consistently found. All sample plots were located within the Nass Basin or Nass Ranges ecosections, with the exception of one, which was located in the Kitimat Ranges ecosection.

Elevation of the plots sampled ranged from 140–625 m. Although many pickers believe that a southerly aspect is most favorable, we found that the sites selected by our guide pickers were located on all aspects, and on level terrain. However, southerly aspects are important in that they commonly provide drier soil conditions, which appears well correlated to productive pine mushroom sites in general.

Slope was found to be of little significance in itself, varying from level to steep. The level terrain was associated with rapidly to very rapidly drained fluvial and glaciofluvial deposits. The middle, upper and crest positions were morainal mantles of various thickness over bedrock, and on glacialfluvial landforms such as kame terraces. While pickers indicated that upper and crest slope positions are often sought out first, they also informed us that once these slope positions have been traversed, the side slopes having similar ecosystems are thoroughly searched for mushrooms.

Soil attributes compared well to previous field studies (Trowbridge and Macadam 1997, Trowbridge and Macadam 1998, Berch 1998). Soil properties described among the sample plots were similar in relation to soil moisture and nutrient regimes, ranging from subxeric to submesic (2–3) for the moisture regime, and submesotrophic (B) for the nutrient regime. Soils were generally coarse textured (sandy loam and loamy sand classes) and commonly had a high coarse fragment content, contributing to rapid drainage and the low moisture and nutrient retention and status found on all sites.

In all but one case, the humus forms were classified as Hemimors, one sample being classified as a Humimor. Mineral soil profiles were in most cases classified as Orthic Humo-Ferric Podzols. Orthic and Eluviated subgroups of Dystric and Eutric Brunisols were also found, but less commonly.

In many cases, charcoal was found at the forest floor-mineral soil interface, indicating the role of fire in stand establishment. Where charcoal was not found, evidence of windthrow on the ground surface, and in turbated soil mineral horizons, was observed. It is possible that stand establishment and structure, in these sample plots, followed disturbance that created significant mineral soil exposure. In some younger, denser stands containing older veterans, lower intensity ground fires may have been responsible for present stand structure.

Vegetation

Vegetation data are summarized in Tables 2 and 3. Detailed data for each plot sampled are given in Appendix 2. Crown cover (A layer) in the plots included in this sample varied from 30% in a partially cut stand, up to a maximum of 85%. Overall, values tended to be somewhat lower in CWHws1 plots (53% on average) compared to those observed in plots in the ICHmc1 (67%) and ICHmc2 (78%) variants. Western hemlock (*Tsuga heterophylla*) was the only tree species observed in all sample plots, and was consistently the dominant species. Lodgepole pine (*Pinus contorta*) was present in over half of all the plots sampled, though in most cases with relatively low cover values. Constancy of Pl was highest in CWHws1 samples. The only deciduous tree species encountered with a constancy ≥ 0.33 was paper birch

(*Betula papyrifera*). Shrub species were not present in great abundance in any of the samples, and total cover values across all biogeoclimatic units averaged <2%. The species most frequently present include black huckleberry (*Vaccinium membranaceum*), falsebox (*Paxistima myrsinites*), false azalea (*Menziesia ferruginea*), and the dwarf shrubs prince's-pine (*Chimaphila umbellata*) and twinflower (*Linnaea borealis*).

Herb cover tended to be extremely low, averaging 0.7% overall. Bunchberry (*Cornus canadensis*), and rattlesnake plantain (*Goodyera oblongifolia*) were encountered most frequently, with constancies across all three areas of 0.52 and 0.38 respectively.

Total moss cover was most commonly >90%, but in one case was as low as 60%. Two species were by far the most common: step moss (*Hylocomium splendens*), which was found in all plots, and red-stemmed feathermoss (*Pleurozium shreberi*), found in all but two plots.

Table 1. Summary of environmental attributes.

Ecological classification

Biogeoclimatic unit	**ICHmc1**	**ICHmc2**	**CWHws1**
Site series and phase [1]	01b Hw - Step moss (Submesic) (5)	01b Hw - Step moss (Submesic) (9)	03a HwPl - Feathermoss (Glaciofluvial) (5) 03a HwPl - Feathermoss (Typic) (2)
Ecosection	Nass basin	Nass Basin, Nass Ranges	Nass Ranges, Kitimat Ranges
Site attributes			
Elevation (m)	140–460	320–625	120–250
Aspect (degrees)	variable	none – variable	none to variable
Slope (%)	0–50	0–30	0–80
Meso slope position [2]	upper and crest, middle, lower	upper and crest, middle, level	level and upper–crest, middle
Soil attributes			
Moisture regime	3	3	2–3
Nutrient regime	B	B	B
Drainage class [2]	rapidly – well	rapidly – well	very rapidly – well
Texture (0–30 cm) [2]	sandy loam – loamy sand	sandy loam, loamy sand, loam	loamy sand – sandy loam
Coarse fragments (0–30 cm)	0–60%	20–70%	0–80%
Soil Classification			
Terrain [2]	morainal veneer, morainal blanket, glaciofluvial blanket	morainal blanket, morainal veneer, glaciofluvial terrace	glaciofluvial blanket, morainal mantles of various thickness
Soil pedon [2]	Orthic Humo-Ferric Podzol, Eluviated Dystric Brunisol, Orthic Dystric Brunisol	Orthic Humo-Ferric Podzol, Eluviated Dystric Brunisol	Orthic Humo-Ferric Podzol, Orthic and Eluviated Eutric Brunisol
Humus form [2]	Hemimor	Hemimor	Hemimor, Humimor

[1] The number in parentheses indicates the number of plots in which the ecosystem unit occurred.
[2] Listed in order of prevalence.

TABLE 2. Constancy[1] of tree, shrub, herb, moss and lichen species appearing in at least 33% of the plots in at least one of the biogeoclimatic units

	ICHmc1	ICHmc2	CWHws1	All BGC units
Tree species	- - - - - - - - - -	Constancy	- - - - - - - - - -	
Tsuga heterophylla	1.00	1.00	1.00	1.00
Pinus contorta	0.60	0.33	0.86	0.57
Thuja plicata	0.00	0.33	0.57	0.33
Betula papyrifera	0.40	0.33	0.14	0.29
Picea spp.[2]	0.00	0.33	0.00	0.14
Shrub species[3]				
Vaccinium membranaceum	0.80	0.44	0.29	0.48
Chimaphila umbellata	0.60	0.44	0.43	0.48
Paxistima myrsinites	0.80	0.33	0.29	0.43
Menziesia ferruginea	0.40	0.44	0.29	0.38
Linnaea borealis	0.40	0.33	0.29	0.33
Rosa acicularis	0.40	0.22	0.00	0.19
Herb species				
Cornus canadensis	0.60	0.67	0.29	0.52
Goodyera oblongifolia	0.60	0.33	0.29	0.38
Clintonia uniflora	0.20	0.56	0.00	0.29
Orthilia secunda	0.20	0.33	0.14	0.24
Pyrola asarifolia	0.20	0.33	0.14	0.24
Platanthera orbiculata	0.00	0.33	0.00	0.14
Moss and lichen species				
Hylocomium splendens	1.00	1.00	1.00	1.00
Pleurozium schreberi	0.80	1.00	0.86	0.90
Ptillium crista-castrensis	0.80	0.78	0.00	0.48
Rhytidiadelphus triquetrus	0.40	0.56	0.29	0.43
Dicranum fuscescens	0.20	0.33	0.43	0.33
Peltigera aphthosa	0.60	0.33	0.14	0.33
Rhytidiadelphus loreus	0.00	0.11	0.43	0.19

[1] Constancy is the proportion of plots in which the species appeared.

[2] White and Sitka spruce have become hybridized in subzones that are transitional between coastal and interior conditions. The characteristics of *Picea* spp. in the ICHmc1 and -mc2 variants tend to more closely resemble those of *Picea glauca*, while closer to the coast in the CWHws1, the genetic features of *Picea sitchensis* are more apparent. *Picea* spp. in the ICHmc subzone are referred to as *Picea glauca x sitchensis*, and those in the CWHws1 as *Picea sitchensis x glauca*.

[3] Including dwarf shrub species considered part of the C layer

TABLE 3. Percent cover of vegetation by layer

	ICHmc1	ICHmc2	CWHws1	All BGC units
Vegetation layers	- - - - - - - - - - - -	(% cover)	- - - - - - - - - - - -	
A (trees > 10 m)	67	78	53	67
B (trees < 10 m)	3.0	10	16	10
B (shrub spp. > 15 cm tall)	2.8	1.6	0.8	1.6
C (herbs, dwarf shrubs)	0.5	0.7	0.7	0.7
D (mosses, lichens)	92	88	86	88

Results obtained in this study are similar in many ways to data obtained in pine mushroom habitat research elsewhere in the province (Berch 1998), for example:

- crown closure is variable, neither consistently high or low
- western hemlock and/or lodgepole pine are commonly present in all of the areas sampled, though in the Bella Coola valley, Nahatlatch, Pemberton, and Nakusp areas, Douglas fir (*Pseudotsuga menziesii*) is often the dominant species.
- Deciduous tree species are not commonly part of the stand, and are never present in abundance, though paper birch (*Betula papyrifera*) is present in some areas.
- Shrub and herb species tend to have low to very low cover values.
- Species commonly found in all areas include the shrubs: black huckleberry (*Vaccinium membranaceum*), falsebox (*Paxistima myrsinites*), false azalea (*Menziesia ferruginea*), the dwarf shrubs: prince's-pine (*Chimaphila umbellata*) and twinflower (*Linnaea borealis*), and the herbs: bunchberry (*Cornus canadensis*), and rattlesnake plantain (*Goodyera oblongifolia*).
- Moss cover, though very high in many of the samples, was not consistently high. Step moss (*Hylocomium splendens*) and/or red-stemmed feathermoss (*Pleurozium shreberi*) were the dominant species found in all areas except the Chilcotin.

Soil profile descriptions

Soil profile descriptions (FS 882's) for all sample plots are represented by three modal soil profile descriptions presented in Appendix 4.

Forest floors ranged from 2–10 cm in thickness, the moderately decomposed Fm horizon(s) being most predominant in the humus form profile. White, gray, and yellow fungal mycelia were generally visible and abundant in the Fm horizons, and held the fabric together in a matted structure. Common to these forest floors was a conspicuous 2–4 cm thick layer of living bryophytes (S layer), and very sparse understory vegetation. Fruiting bodies of *T. magnivelare* grew through the thinner forest floors and were observed to have matured and released spores above the ground surface. However, where the forest floors were thicker, it was observed that mushrooms matured completely within the fabric of the forest floor itself.

Mineral soil horizons were coarse textured, generally loamy sand to sandy loam and often contained more than 35% coarse fragments by volume. This, in combination with slope position and surface shape, contributes to soils being consistently well to very rapidly drained.

Pine mushrooms were always observed to be solidly "rooted" in the surface mineral horizon (Ae or B), surrounded by masses of grayish fungal mycelia. The surface mineral horizon was most commonly a thin to thick (1–8 cm) Ae horizon, coarse textured, grayish coloured and acidic (pH 4–4.5[3]). Brown to reddish brown Bm and Bf horizons were always present in the soil profile, sometimes at the surface where the profile lacked an Ae horizon. The surface B horizons were generally less acidic (pH 5–6) when compared to the associated Ae horizons. Where fungal mycelia were observable in B horizons (generally in distinct pockets), the immediate soil matrix was more acidic than the associated non-fungal soil matrix by 0.5 to 1.0 pH units. In addition, fungal-rich mineral soil matrix was hydrophobic (repelling water).

Below the surface soil horizons and the effective rooting zone (25–40 cm), the profiles generally increased in coarse fragment content, showed less pronounced soil development, and graded towards either nearly unaltered parent material, or bedrock.

Stand characterization

Stand ages ranged from 70 to 230 years (Appendix 3), with many sites in the 80 to 160 year range (Fig. 1). Some stands were even-aged, while others had veterans mixed with younger trees. Some pickers have commented that, in their experience, pine mushrooms drop out in old-growth (>250 years) forests. We have found pine mushrooms in old-growth stands, but the frequency of mature stands in the range of 80-160 years in our survey does suggest better conditions occur in this age range. As yet, we do not know when pine mushrooms reappear in young forests.

Overall, the stands were less productive than typically found for zonal sites, as would be expected for the submesic site series we sampled. Site indices for western hemlock averaged 12 metres at 50 years (Table 4), which is less than the site index of 15 and 20 expected for zonal sites in our ICH and CWH subzones, respectively (SIBEC 1997). Similarly, site indices for lodgepole pine averaged 14.4, less than the expected site index of 21 and 20 for zonal sites in these ICH and CWH subzones, respectively.

FIGURE 1. Frequency of sampled stands occurring in each age class.

TABLE 4. Average stand characteristics by biogeoclimatic unit.

	ICHmc1	**ICHmc2**	**CWHws1**	**All BGC units**
Net volume (m^3)	317	475	387	393
Basal area (m^2)	53	61	51	55
Height (hemlock only) (m)	19	25	22	22
Site index (bh)				
Western hemlock	10.3	12.6	11.7	11.8
Lodgepole pine	12.6	-	15.5	14.4

Across the 21 sites, stands averaged approximately 400 m^3 net volume per ha and 55 m^3 basal area per ha, which is also likely below average for zonal sites. Stand health good in many cases, but some stands had a high incidence of conks on stems of western hemlock, especially on older trees.

In general, stands were quite variable in terms of age, structure and productivity, suggesting that these parameters are less useful than ecological characteristics and site series classification for identifying productive pine mushroom habitat.

[3] pH was estimated in the field using the Hellige-Truog method.

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APPENDIX 1. Summary of environmental characteristics

	ICHmc1 subzone					*ICHmc2 subzone*									*CWHws1 subzone*						
Plot name:	**Bord 1**	**Bord 2**	**Harp**	**Bear**	**Derr**	**Fidd**	**Susk**	**Date**	**Robi**	**Hele 1**	**Hele 2**	**Cran**	**Corr**	**Shan**	**Grav**	**Glac**	**Ross**	**Ceda**	**Air**	**Klea 1**	**Klea 2**
Site series	01b	01b	01b	01b	01b	01b	01b	01b	01b	01b	01b	01b	01b	01b	03B	03B	03a	03a	03b	03b	03b
Ecosection	NAB	NAB	NAB	NAB	NAB	NAR	NAB	NAB	NAB	NAB	NAB	NAB	NAB	NAB	NAR	NAR	NAR	NAR	KIR	NAR	NAR
Elevation	140	399	270	355	459	330	625	386	322	435	502	369	538	380	229	199	246	233	202	122	162
Slope	0-5	5-22	10-23	5-50	0-70	2	27	12	0	12	5-10	5	27	16	0-1	60	0-5	18	0	2	80
Aspect	312	158	var.	var	var	296	346	65	none	180	100	223	320	270	none	226	40	192	none	330	144
Mesoslope position	LV	MD	UP	UP-CR	CR-UP	CR-UP	MD	UP-CR	LV	UP-CR	CR-UP	CR	M	UP	LV	UP	CR	UP-CR	LV	LV	MD
Soil nutrient regime	3	3+	3	3-	3-	3	3-	3	3	3-	3-	3	3-	3	3-	2	3	2	3	3	2+
Soil moisture regime	B	B+	B+	B-	B-	B	B	B+	C-	B	B-	B+	B	B+	B	B	B	B	B	B+	B+
Drainage class	r	w	w-r	r	r	r	r	r	w	r	w-r	w	r	w-r	w-r	x	w-r	x	r	r	r
Rooting zone particle size	S	CLS	CL	CLS	CLS	CLS	SS	CL(S)	CLS	CLS	CLS	CLS	CLS	CLS	CLS	CLS	CL	SS	CL	CLS	SS
Terrain classification	FGb	Mv	Mb(v)	Mv	Mv-Cv	Mb	Mb	Mb	Ft	Mv(b)	Mv	Mb	Mv	Mb	FGt	FGb	Mw	Mw	FGb	FGb	FGb
Soil classification	E.DYB	O.FHP	O.FHP	O.DYB	E.DYB	O.HFP	O.HFP	O.HFP	O.HFP	E.DYB	O.HFP	O.HFP	O.HFP	O.HFP	O.HFP	O.HFP	O.HFP	E.EB	O.HFP	O.HFP	O.EB
Humus form classification	HR	HR	HR	HR	HR	HR	HR	HR	HR	HR	HR	HR	HR	HR	HR	UR	HR	HR	HR	HR	HR

Coding (B.C. Ministry of Environment, Lands, and Parks and B.C. Ministry of Forests 1998)**:**

Ecosection	Mesoslope	Drainage	Rooting zone particle size	Terrain	Soil	Humus form
NAB - Nass Basin	CR - crest	x - very rapidly	S - sandy	C - colluvium	O.DYB - Orthic Dystric Brunisol	HR - Hemimor
NAR - Nass Ranges	UP - upper	r - rapidly	SS - sandy-skeletal	F - fluvial	E.DYB - Eluviated Dystric Brunisol	UR - Humimor
KIR - Kitimat Ranges	MD - middle	w - well	CL - coarse-loamy	FG - glaciofluvial	O.HFP - Orthic Humo-Ferric Podzol	
	LW - Lower		CLS - coarse-loamy-skeletal	M - morainal		
	LV - Level			b - blanket		
				t - terrace		
				v - veneer		
				w - variable thickness		

APPENDIX 2. Detailed vegetation data

Table 1. Total vegetation cover by layer and percent cover and constancy[1] of tree and shrub species appearing in at least 33% of plots in at least one subzone.

	Bord 1	Bord 2	Harp	Bear	Derr	CHmc1	Fidd	Susk	Date	Robi	Hele 1	Hele 2	Cran	Corr	Shan	ICHmc2	Grav	Glac	Ross	Ceda	Air	Klea 1	Klea 2	CWHws 1	Average for all subzones
	ICHmc1 subzone						*ICHmc2 subzone*										*CWHws1 subzone*								
Layer of vegetation	------ (% cover) ------					**Avg.**	------------- (% cover) -------------									**Avg.**	---------- (% cover) ----------							**Avg.**	
A (trees > 10 m)	75	75	60	65	60	67	80	85	75	73	75	80	78	75	80	78	60	60	38	30	50	45	85	53	67
B (trees < 10 m)	1	0.2	1.2	4	8.8	3.0	1.1	15	33	1.5	0.6	0	25	0	12	10	5	5	1	35	30	24	15	16	10
B (shrub spp. > 15 cm tall)	7.4	0	1.3	3.1	2.4	2.8	2.1	0	2.5	0.53	0	2	4	3.5	0.01	1.6	1	2.5	0.1	0.01	0.22	0.02	1.8	0.8	1.6
C (herbs, dwarf shrubs)	1	0.002	0.3	0.02	1	0.5	1	0.01	0.5	0.03	0.001	2.4	2.5	0.3	0	0.7	0	2	0.01	0	0	3	0.0	0.7	0.7
D (mosses, lichens)	70	98	96	97	98	92	95	85	90	98	98	95	95	90	45	88	90	70	95	96	96	98	60	86	88
Tree species	------ (% cover) ------					**Const.**[1]	------------- (% cover) -------------									**Const.**	---------- (% cover) ----------							**Const.**	**Const.**
Tsuga heterophylla	70	40	52	50	60	1.00	60	85	75	50	68	80	76	75	30	1.00	45	55	35	28	30	25	62	1.00	1.00
Pinus contorta		30	7	15		0.60	2			5		3				0.33	15	6		2	20	20	13	0.86	0.57
Thuja plicata						0.00	6				0.5				11	0.33		1	3			1	10	0.57	0.33
Betula papyrifera	5	3				0.40	1			10					1	0.33							2	0.14	0.29
Picea spp.[2]						0.00				6			0.8		3	0.33								0.00	0.14
Shrub species[3]																									
Vaccinium membranaceum	1		0.2	0.1	1.5	0.80			1			0.5	0.1	0.1		0.44	0.001	1.5						0.29	0.48
Chimaphila umbellata			0.2	0.01	0.8	0.60	0.1			0.01		1.5	0.05			0.44		0.8				0.2	0.1	0.43	0.48
Paxistima myrsinites	4		1	1	0.5	0.80			3					2	0.01	0.33				0.01			0.8	0.29	0.43
Menziesia ferruginea	2		0.1			0.40	0.1		0.8			1.5		1.5		0.44	1		0.1					0.29	0.38
Linnaea borealis	0.1				0.1	0.40						0.1	0.3	0.001		0.33		0.3				2.4		0.29	0.33
Rosa acicularis				0.02	0.2	0.40			0.2	0.02						0.22								0.00	0.19

[1] Constancy is the proportion of plots in which the species appeared.

[2] White and Sitka spruce have become hybridized in subzones that are transitional between coastal and interior conditions. The characteristics of *Picea* spp. in the ICHmc1 and mc2 subzones tend to more closely resemble those of *Picea glauca*, while closer to the coast in the CWHws1 subzone, the genetic features of *Picea sitchensis* are more apparent. *Picea* spp. in the ICHmc subzones are therefore referred to as *Picea glauca x sitchensis*, and those in the CWHws1 as *Picea sitchensis x glauca*.

[3] Including dwarf shrub species considered part of the C layer

Table 2. Percent cover and constancy[1] of herb, moss, and lichen species appearing in at least 33% of plots in at least one subzone.

	ICHmc1 subzone						*ICHmc2 subzone*										*CWHws1 subzone*								
	Bord 1	**Bord 2**	**Harp**	**Bear**	**Derr**	**ICHmc1**	**Fidd**	**Susk**	**Date**	**Robi**	**Hele 1**	**Hele 2**	**Cran**	**Corr**	**Shan**	**ICHmc2**	**Grav**	**Glac**	**Ross**	**Ceda**	**Air**	**Klea 1**	**Klea 2**	**CWHws 1**	**Const. all**
Herb species	- - - - - - (% cover) - - - - - -					**Const.**	- - - - - - - - - - - - - (% cover) - - - - - - - - - - - - -									**Const.**	- - - - - - - - - - (% cover) - - - - - - - - - -							**Const.**	**subzones**
Cornus canadensis	0.1			0.01	0.05	0.60	0.1		0.2	0.001		0.5	1.5	0.1		0.67		0.2					0.01	0.29	0.52
Goodyera oblongifolia	0.2	0.002			0.1	0.60	0.1	0.01					0.3			0.33		0.2				0.1		0.29	0.38
Clintonia uniflora	0.1					0.20	0.2		0.1			0.05	0.3	0.02		0.56								0.00	0.29
Orthilia secunda			0.1			0.20			0.01			0.05		0.1		0.33						0.1		0.14	0.24
Pyrola asarifolia			0.001			0.20					0.001	0.1		0.001		0.33		0.4						0.14	0.24
Platanthera orbiculata						0.00			0.001			0.01	0.005			0.33								0.00	0.14
Moss and lichen species																									
Hylocomium splendens	30	35	40	35	40	1.00	30	60	50	55	70	55	40	65	25	1.00	84	45	87	75	30	60	55	1.00	1.00
Pleurozium schreberi		33	45	32	40	0.80	25	10	20	0	3	20	30	25	3	1.00	5	25	3	20	65	20		0.86	0.90
Ptillium crista-castrensis	15	30		30	15	0.80	5	10	20	20	23	20	15			0.78								0.00	0.48
Rhytidiadelphus triquetrus	20		8			0.40	4			23	2		10		10	0.56						20	5	0.29	0.43
Dicranum fuscescens	5					0.20	4	2							2	0.33	0.02			0.5	1			0.43	0.33
Peltigera aphthosa			0.5	0.02	2	0.60		1		0.001		1				0.33		0.5						0.14	0.33
Rhytidiadelphus loreus						0.00	3									0.11	1		3	0.5				0.43	0.19

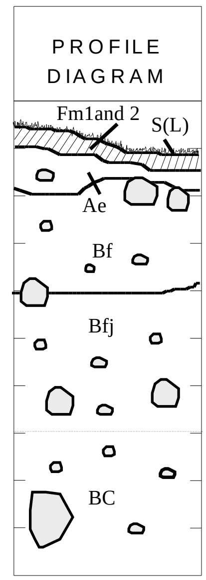
[1] Constancy is the proportion of plots in which the species appeared.

APPENDIX 3. Stand characteristics

	ICHmc1 subzone					*ICHmc2 subzone*									*CWHws1 subzone*						
Plot name:	**Bord 1**	**Bord 2**	**Harp**	**Bear**	**Derr**	**Fidd**	**Susk**	**Date**	**Robi**	**Hele 1**	**Hele 2**	**Cran**	**Corr**	**Shan**	**Grav**	**Glac**	**Ross**	**Ceda**	**Air**	**Klea 1**	**Klea 2**
Stand age (years)	84	84/99	121/204	140	130/166	74	149/208	190	69/145	114	202	152	237	153	124	114/191	117	95	164	98/120	145
Net volume (m^3)	504	374	258	249	201	581	294	386	459	381	593	599	N/a	509	468	305	719	133	236	411	346
Basal area (m^2)	67.2	60	41	53	45	76	50	60	60	52	71	64		58	45	53	81	32	42	55	40
Height (hemlock only) (m)	21.1	21.6	13.4	18	22.7	24.5	19.9	23.0	27.5	21.6	27.1	24.7	32.5	26.2	26.8	15.0	27.0	10.6	21.1	25.1	24.5
Site index (m@50yr)																					
Western hemlock	14.1	12.7	5.9	7.7	10.9	18.4	6.9	8.2	22.1	11.3	10.4	11.0	13.3	12.0		8.6	15.5	6.9		15.0	12.5
Lodgepole pine		15.3	9.5	12.9											18.3	15.9		13	11.7	18.5	

APPENDIX 4. Modal soil profile descriptions

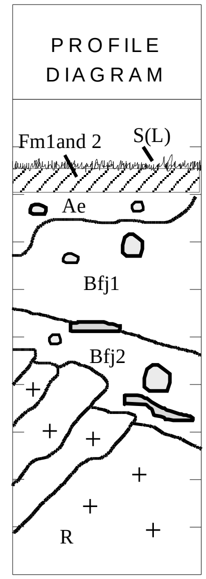
1. Morainal blanket, Orthic Humo-Ferric Podzol, Hemimor. Located in the ICHmc2 variant (Nass Basin ecosection), 01b site series, 625 m elevation, 27% slope.



Horizon	Depth (cm)	Description
S(L)	3	Dominantly *Hylocomium splendens* moss intermixed with few needles and fine branches.
Fm1	8–6	Weak compact matted, firm, slightly decomposed fibric material comprised of mosses with few needles and cones, common mycelia, plentiful fine to medium roots.
Fm2	6–2	Moderate compact matted, firm, slightly decomposed fibric material, common to abundant mycelia, plentiful fine to medium roots, charcoal present.
Ae	0–8	Dark gray (10YR 4/1, moist); loamy sand; 30% coarse fragments; few fine and medium roots; very fine subangular blocky; hydrophobic; abrupt, smooth boundary; pH 4.5[4].
Bf	8–30	Dark yellowish brown (10YR 4/6, moist); loamy sand; 45% coarse fragments; plentiful fine and medium roots; very fine subangular blocky; common gray mycelia; hydrophobic in fungal-rich soil matrix; clear, smooth boundary; pH 6.5.
Bfj	30–60	Olive brown (2.5Y 4/4, moist); sand; 55% coarse fragments; plentiful fine and medium roots; very fine subangular blocky; common gray mycelia; clear, smooth boundary; pH 5.0.
BC	60–70+	Light olive brown (2Y 5/4, dry); sand; 60% coarse fragments; few fine and medium roots; single grain.

[4] pH's were field estimated using the Hellige-Truog method.

2. Morainal veneer, Eluviated Dystric Brunisol, Hemimor. Located in the ICHmc1 variant (Nass Basin ecosection), 01b site series, 459 m elevation, variable slope (0–27%) on upper to crest slope position.

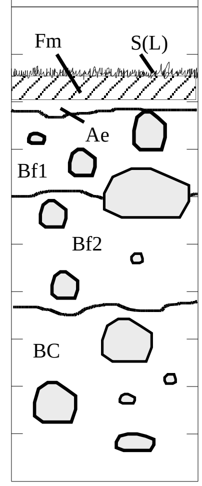


Horizon	Depth (cm)	Description
S(L)	3	*Hylocomium splendens, Ptillium crista-castrensis, and Peltigera aphthosa* mosses intermixed with needles and fine branches.
Fm1	5–4	Moderate compact matted, firm, slightly decomposed fibric material comprised of mosses with few needles and cones, common white and yellow mycelia, plentiful fine to medium roots.
Fm2	4–0	Strong compact matted, firm, slightly decomposed fibric material, abundant white and yellow mycelia, plentiful to abundant fine to medium roots.
Ae	0–5	Light olive brown (2Y5/4, moist) to light yellow brown (10YR6/4, dry); sandy loam; 40% coarse fragments; few fine and plentiful medium roots; single grain; abundant gray mycelia: hydrophobic; abrupt, smooth boundary; pH 4.0.
Bfj1	5–26	Dark yellowish brown (10YR 4/5, moist); sandy loam; 50% coarse fragments; plentiful fine and few coarse and medium roots; weak, fine subangular blocky; few gray mycelia (pockets); clear, smooth boundary; pH 5.3.
Bfj2	26–(32)42	Dark yellowish brown (10YR 4.5/4, moist); sandy loam; 60% coarse fragments; few fine and medium roots; weak, fine subangular blocky; gradual, irregular boundary; pH 5.8.
R	(32)42+	Fractured shale bedrock.

3. Glaciofluvial terrace, Orthic Humo-Ferric Podzol, Hemimor. Located in the CWHws1 variant (Nass Ranges ecosection), 03b site series, 229 m elevation, 0–1% slope.

Horizon	Depth (cm)	Description
S(L)	4	Dense, dominantly *Hylocomium splendens* moss intermixed with needles and fine branches.
Fm	4–0	Strong compact matted, firm, moderately decomposed fibric material, plentiful mycelia, plentiful fine, medium, and coarse roots.
Ae	0–1	Gray (10YR6/1, moist), sandy loam; single grain; abrupt, clear boundary; pH 4.0.
Bf1	1–20	Dark brown (7.5YR 4/4, moist); sandy loam 40% coarse fragments; weak, coarse subangular blocky; clear, smooth boundary; pH 4.5.
Bf2	20–32	Dark brown (7.5YR 4/4, moist); sandy loam; 60% coarse fragments; few fine and medium roots; weak, medium to coarse subangular blocky; clear, smooth boundary; pH 6.0.
BC	32–55+	Dark grayish brown (2.5Y4/2, moist); sand; 40% coarse fragments; single grain; pH 6.8.

PROFILE DIAGRAM



SECTION D. PINE MUSHROOMS AND TIMBER PRODUCTION IN THE CRANBERRY TIMBER SUPPLY AREA, PRINCE RUPERT FOREST REGION

Gerrard Olivetto, Olivetto Timber, Victoria, British Columbia

METHODS

A forest estate model assembles a description of the forested land base, and assumptions about growth and productivity of organisms on that land base. Within the model, time is projected forward, and changes to habitats and organism responses are monitored. Time increments used in this analysis are 10-year periods. Each decade, forests grow 10 years older, and some forest stands are harvested and replaced with regenerating stands. The state of the forest in each period determines its ability to produce timber, mushrooms, and other values.

FOREST AREAS AND VOLUMES

Figure 1 illustrates the present forest age class distribution on the timber harvesting land base (THLB) in the CTSA. The THLB is a subset of the total forested area, after deducting streamside buffers, other environmentally sensitive areas, low-producing sites and protected areas. The total area of the CTSA is 77 000 ha, the forested area is 60 000 ha, and the THLB is 32 832 ha, or 55% of the total forested area. Within the THLB, most of the forest is presently mature (greater than 120 years old), and 23% is presently less than 30 years old.

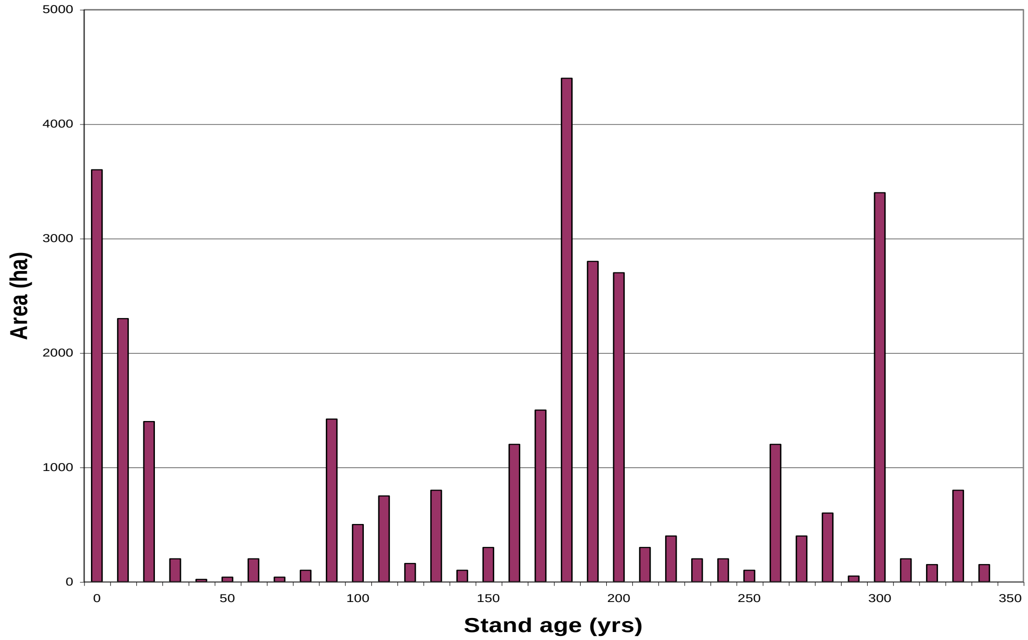


FIGURE 1. Age-class distribution on the timber harvesting land base, Cranberry TSA.

The rates of timber growth and yield on this area are estimated using the Table Interpolation Program for Stand Yields (TIPSY), with a site index of 14.0 and operational adjustment factors (OAF 1 and 2) of 15 and 15, respectively. Trowbridge et al. (1999) sampled 21 highly productive pine mushroom sites near the CTSA during an earlier phase of this integrated project. They found site index ranging from 10.3 to 15.5 m at 50 years breast height age in the sample plots, and standing volumes ranging from 317 to 475 m^3/ha. The *Cranberry TSA Timber Supply Analysis* (B.C. Ministry of Forests 1997) estimated present average harvested yields at 440 m^3/ha. Figure 2 illustrates the TIPSY yield curve used in this model.

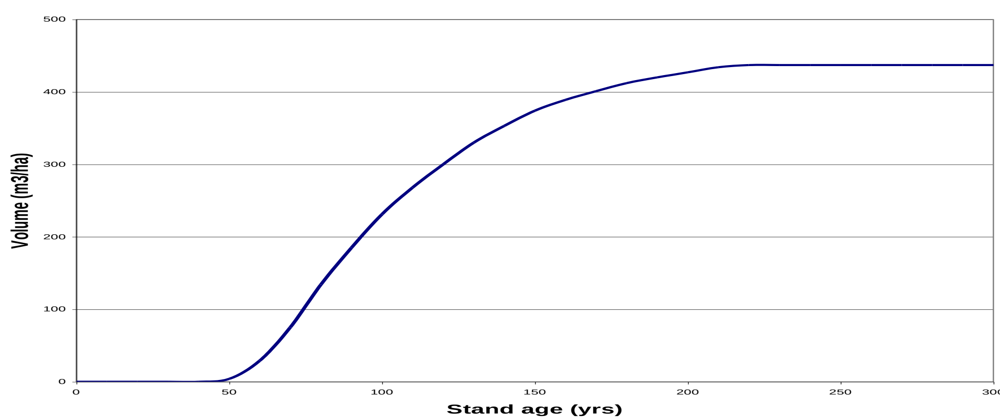


FIGURE 2. Stand volume development, Cranberry TSA.

The economic module of the TIPSY program was used to estimate timber values over time. Larger trees, produced later in stand development, have higher grade value. Assumptions input to TIPSY include default harvesting, hauling and milling costs for the Kispiox Forest District, and lumber values of $450 per thousand board feet (Madison's Online 1999). Figure 3 illustrates the economic value of standing timber over time.

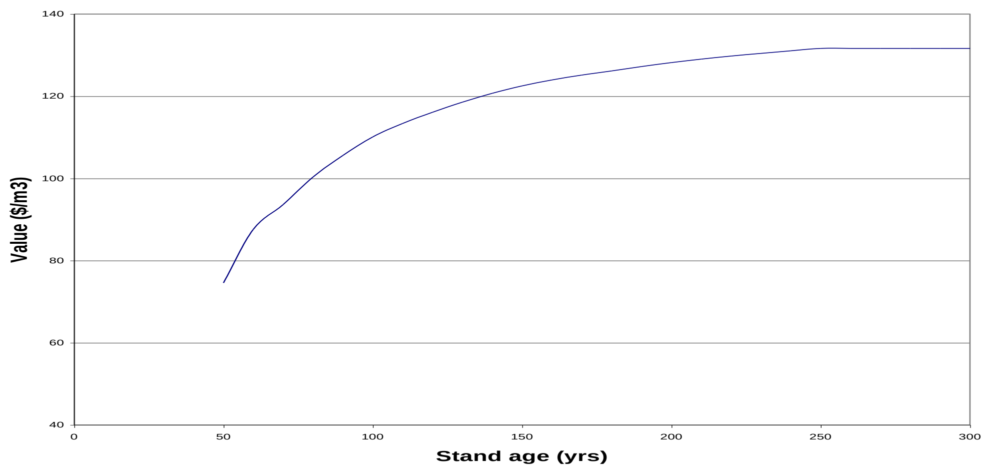


FIGURE 3. Standing timber values as potential economic activity through the complete manufacturing process.

Presently, the CTSA contains a total of 10.2 million m^3 of merchantable standing timber, with a potential economic value (i.e., value that could be realized if all the timber was converted to lumber and sold at current market prices) of $1.3 billion.

PINE MUSHROOM YIELDS

Mushroom yields are modelled as a function of stand age. Trowbridge et al. (1999) found that among 21 sample plots visited in the fall of 1998, most producing stands were aged between 81 and 160 years old, although some stands were up to 240 years of age. The sites visited are all known to produce pine mushrooms in commercial quantities. Figure 4 is copied from Trowbridge et al.'s (1999) findings of frequency of highly productive pine mushroom sites across the range of observed age classes.

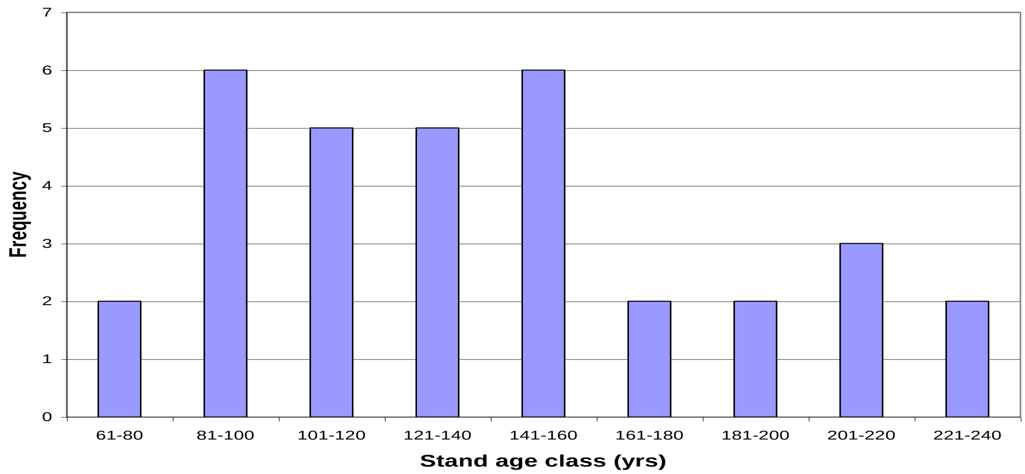


FIGURE 4. Frequency of sampled stands occurring in each age class (Trowbridge et al. 1999).

Stands that produce pine mushrooms in the CTSA are generally greater than 60 years old. After that age, production rises rapidly, and continues at a high rate until approximately 160 years of age, after which production declines. Comparing Figure 4 with Figure 1, one may conclude that production declines to a very low level by 200 years of age. Stands older than 160 years are well represented in the inventory, but occur infrequently in the samples. The information in Figure 4 was scaled to the existing age-class distribution (frequency of occurrence is divided by the existing area, by age class, and scaled so maximum yields are 100%) and smoothed to a continuous curve. Figure 5 illustrates the scaling and smoothing steps in developing a *relative* yield curve for pine mushrooms in the CTSA.

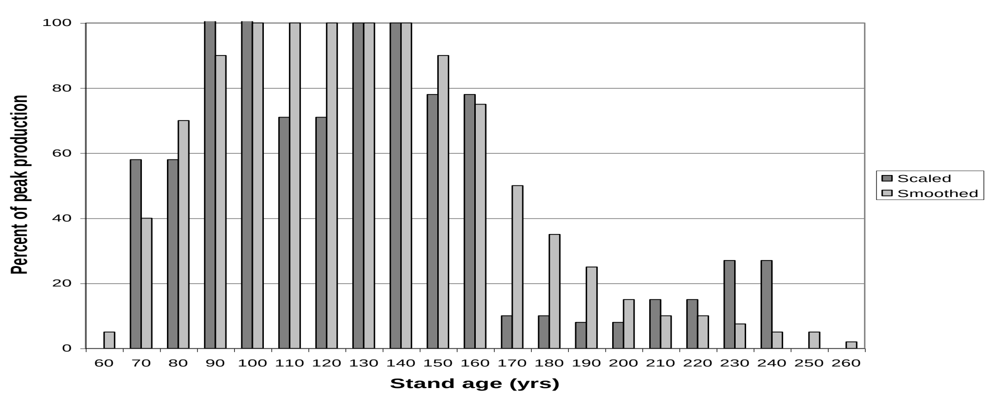


FIGURE 5. Frequency data (Trowbridge et al. 1999) scaled to the land base, and smoothed to a gentle curve

The smoothed shape in Figure 5 illustrates a first approximation of the shape of a pine mushroom yield curve for the CTSA. However, it does not indicate the magnitude of expected yields. Trowbridge et al. did not measure pine mushroom yields in their plots. Yields for this analysis are estimated using the following observations. Mushroom buying camps operate in the CTSA each year during September and October.

The main camp is at Cranberry Junction, and two other buying camps are usually located north of Borden Mountain. Some of the crop delivered to Cranberry Junction originates outside the CTSA, particularly mushrooms picked farther north. In an average year 4000 pounds per day for 50 days (Tsunami Mushroom Co., pers. comm.) are brought to Cranberry Junction.

Judging by the map in Appendix 1, the forest area from which mushrooms are picked and delivered to Cranberry Junction is approximately twice the area of the CTSA. An estimate of annual production from the CTSA would therefore be half the total delivered product, or 100 000 pounds (45 000 kg). The THLB covers 55% of the forested area so an unbiased estimate would be that 25 000 kg/yr of pine mushrooms are harvested from the timber harvesting land base.

Figure 5 illustrated productive forest ages. Cross-multiplying the present age class distribution (Figure 1) by the relative production (Figure 5), and solving for a total yield of 25 000 kg, indicates that natural yields through the peak productivity age range presently average 3.5 kg/(ha·yr). This yield figure assumes that pine mushrooms are produced in all forest stands. An alternative assumption, that the mushrooms come from concentrated patches, would indicate yields of 25 kg/(ha·yr), and is tested later in the report. The derived "average" yield curve for pine mushrooms in the CTSA is illustrated in Figure 6.

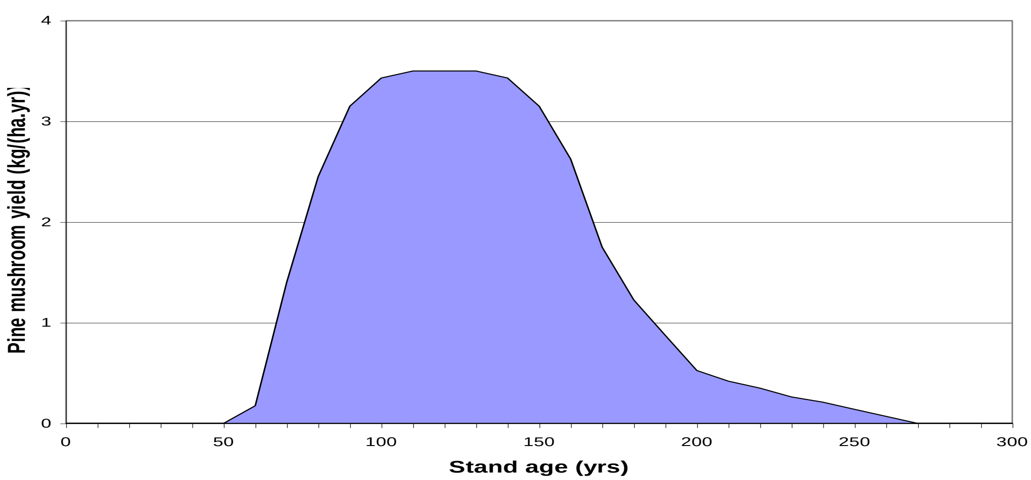


FIGURE 6. Estimated average yield curve for pine mushrooms in the Cranberry TSA.

For this analysis, pine mushrooms are assumed to have an average field price of $15/lb, or $38/kg. Prices in the 1998 picking season ranged from $5/lb to $75/lb, and were between $12 and $20/lb for most of the season. When prices fell below $10/lb, pickers were leaving the area, and prices rose to ensure a labour supply. The total revenue for pine mushroom pickers from the CTSA is estimated to be $950 000/yr.

RESULTS

The 1997 TSR analysis of the CTSA found that a timber harvest rate of 110 000 m^3/yr would be sustainable for 9 decades, declining afterwards to a long-term sustainable harvest level of 87 000 m^3/yr. Harvesting at those rates produces a forest evenly distributed across age classes from 0 to 120 years, with a small amount of area in older age classes due to reduced harvest rates in visually sensitive areas. The 45% of the forest outside the THLB was assumed in the TSR analysis to age indefinitely, and meet biodiversity requirements. Based on that analysis, and other considerations, the present allowable annual cut in the CTSA is 110 000 m^3/yr.

ALTERNATIVE HARVEST RATES

This analysis varies the rate of timber harvesting, and reports expected pine mushroom yields over the next 200 years. Minimum harvest ages are set at 120 years, and an oldest-first harvest priority rule is used. A key assumption is that stands regenerating after timber harvest will experience a rate of colonization by the pine mushroom fungus equal to the colonization rate in existing natural-origin stands.

Figure 7 illustrates expected pine mushroom production from the CTSA under these assumptions, and even-flow harvest projections. To achieve the target harvest levels over the 200-year horizon, minimum harvest ages must be reduced to 110 years for a harvest level of 100 000 m^3/yr, and to 60 years for a harvest level of 105 000 m^3/yr.

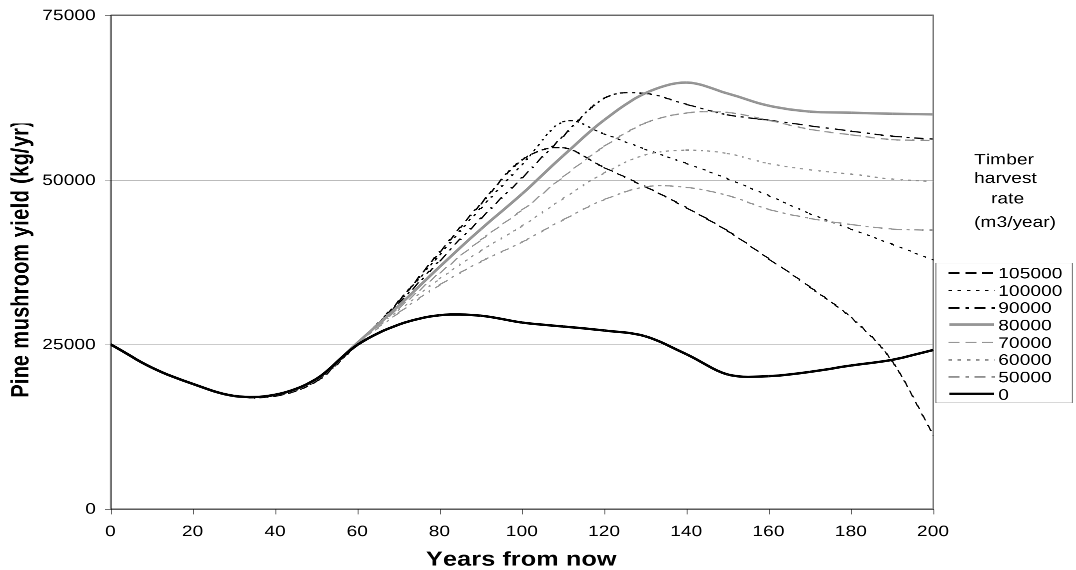


FIGURE 7. Long-term pine mushroom yields with alternative rates of timber harvesting.

Timber harvesting modifies the age-class structure in a forest by replacing old stands with regenerating stands. The rate of harvest controls the rate of regeneration, and the maximum age to which stands are permitted to grow. In the long term, at a harvest rate of 80 000 m^3/yr in the CTSA, stands are harvested when they reach approximately 165 years old. This permits the stands to mature through the age range when pine mushrooms are produced, and results in the highest long-term levels of pine mushroom productivity. In a 500-year projection at a timber harvest rate of 80 000 m^3/yr, pine mushroom production in the CTSA remains between 60 000 and 62 000 kg/yr.

At harvest rates higher than 80 000 m^3/yr, forest rotations are shortened and stands are harvested while still producing mushrooms. At lower harvest rates, less area is being regenerated annually, and therefore less area grows through the pine mushroom productivity phase. The lowest long-term pine mushroom productivity occurs at a timber harvest rate of zero.

LONG-TERM ECONOMIC VALUES

The economic yield from the forest in this two-product model would be the sum of timber and mushroom values. Figure 8 illustrates the long-term (year 200) combined values that would be achieved from the CTSA under the rates of harvest described in the preceding section. Timber value is expressed as the total value of potential lumber yield, and includes stumpage, and economic activity from logging and manufacturing. Mushroom value is the field price paid to the pickers. A more complete estimate would value mushrooms at market prices, once data are available for the valued-added activities of sorting and grading, transportation, and merchandising.

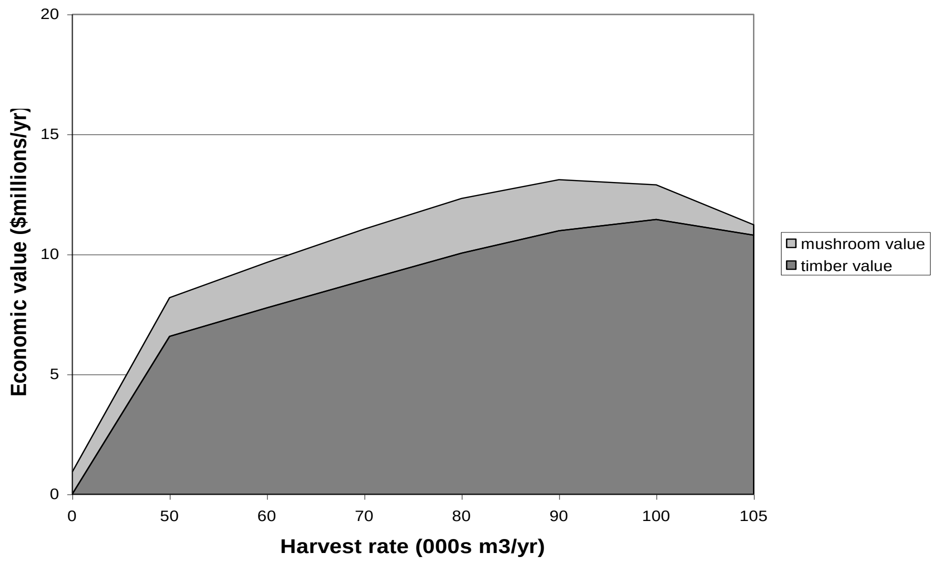


FIGURE 8. Economic yields at year 200 with alternative rates of timber harvesting.

Figure 8 suggests that total forest economic yield would be maximized at a harvest rate of 90 000 m^3/yr. In the long term, at this harvest rate, total annual economic yields would be $10.98 million for timber, and $2.13 million for mushrooms. Rotation ages at this harvest rate are approximately 145 years. Higher rates of harvest reduce value in two ways – by reducing mushroom yields, and by reducing the age at which stands are harvested. Values per cubic metre are less at younger ages (refer to Figure 3).

Note that in Figure 8, both timber and mushroom economic yields rise across the range of harvest levels from 50 000 to 90 000 m^3/yr. Conflicts (higher timber harvest, lower mushroom harvest, and a net loss) only arise at the high-end margin, when timber harvesting is pushing the limits of biological productivity on the land base.

SHORT-TERM HARVEST PROFILE

The pine mushroom yield forecasts illustrated in Figure 7 for the first 50 years are identical at all harvest levels. This is due to the oldest-first harvest priority rule in the model. Considerable area in the CTSA is presently greater than 175 years old. All rates of harvest are satisfied from this older forest, which does not produce significant quantities of pine mushrooms. Therefore, in the first 50 years, harvesting does not negatively impact mushroom yields in the model. The downward slope of the mushroom yield curve over the first 30 years is due to stands that presently produce mushrooms maturing to ages with lower levels of mushroom productivity. If the oldest-first harvest priority rule were an accurate representation of current harvest practices, no conflict would occur between loggers and mushroom pickers.

However, older hemlock stands in the CTSA characteristically have high incidence of conk, and heart and butt rots. Many of the older stands are unsuitable for lumber manufacturing, and are harvested primarily for pulp fibre, if at all. The present age-class distribution in the CTSA (Figure 1) suggests that harvesting has concentrated in younger mature stands. Currently mature stands originated mainly from natural disturbance events and smaller area representation would be expected in older stands, due to the increased likelihood of natural disturbance having occurred sometime during the stand development. Instead, representation is relatively low between 100–170 years.

Present harvest priorities may focus on stands most suited to wood manufacturing. Figure 9 illustrates expected short-term pine mushroom yields in the CTSA if harvest priority is placed on stands aged between 120 and 175 years old. The harvest rate is 80 000 m^3/yr, and a minimum harvest age of 120 years is maintained for both scenarios.

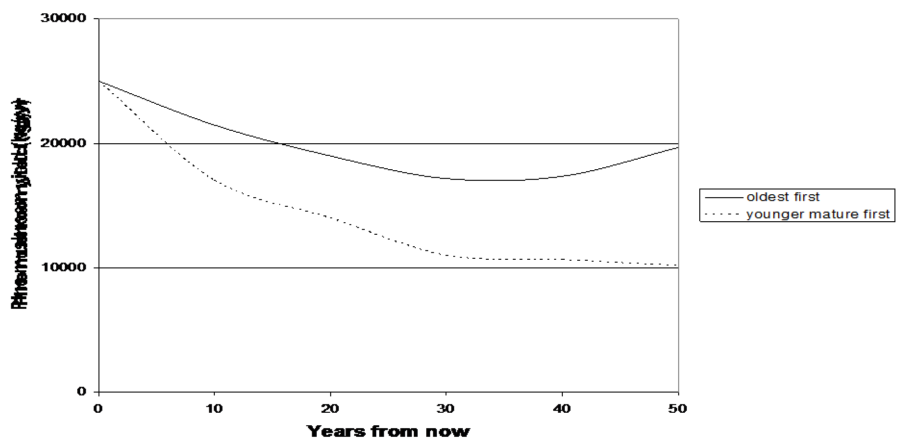


FIGURE 9. Short-term pine mushroom yields with alternative harvest profile assumptions

It is difficult to assess the economic tradeoffs implicit in Figure 9, since the timber valuation curve (Figure 3) does not recognize the deteriorating quality of very old forest in the CTSA. However, it may be assumed that 50 years from now those older stands will be more decadent than at present, and will not be producing pine mushrooms.

PREFERRED HABITAT VERSUS EXTENSIVE COVERAGE

This analysis modelled mushroom productivity from suitable age classes across the entire forested land base. In fact, mushroom occurrence is concentrated in certain areas. Trowbridge et al. (1999) found that where pine mushrooms are found, sites are consistently nutrient poor and drier than typical (zonal) sites. The best habitat is found on the 3B site series, which features coarse-textured, well-drained soils. Within this habitat, pine mushroom occurrence is patchy because of the 50-odd other mycorrhizal species competing for space on the tree root systems. Earlier work by the author (Olivotto Timber 1998) suggested that 15% of natural-origin forest in suitable age classes is colonized by the pine mushroom fungus.

This assumption provides tremendous potential to enhance economic yields from the forest. A majority (85%) of the forest area might be managed to optimize timber production, without consideration of the longer rotation ages needed to enhance pine mushroom production. Rather than the 10% timber harvest rate reduction suggested in Figure 8 (from 100 000 m^3/yr to 90 000 m^3/yr, maximizing timber versus maximizing the combination), timber supply reductions of 1.5% would be adequate to ensure a viable pine mushroom industry.

Pine mushroom occurrence in patches will also influence calculations of the area requiring special management. Rather than 3.5 kg/(ha·yr) across the landscape, mushrooms are produced at a rate of 25 kg/(ha·yr) in the patches, and not at all in other areas. Rather than 8000 ha of producing area, the 32 832 ha timber harvesting land base in the CTSA currently has some 1200 ha of productive pine mushroom patches.

Within the patches, mushroom values (picker revenues) are $950/(ha·yr). Timber management on a 120-year rotation would produce a total economic value of $45 000/ha at the first entry, and $35 000/ha at subsequent entries, or $290–375/(ha·yr). Measured on a sustained yield basis, mushroom values within the patches are triple the value of timber harvesting. However, timber harvesting would still occur, though at a later age.

FURTHER INFORMATION REQUIREMENTS

This project assembled the most basic information required for forest estate modelling of integrated timber and mushroom yield impacts. The discussion highlighted where assumptions were made – readers may have different assumptions. Certain aspects of the model would benefit from more rigorous data inputs. The following steps would improve the analysis of timber/mushroom management:

1. Work to predict site series from other mapped inventory attributes is progressing. Site series 3B is highly correlated with known pine mushroom patches. Predictive maps of pine mushroom patches would enable refinement of the 15% productive area estimate in the report.
2. Better information could be collected about actual pine mushroom volumes and grades harvested from within a catchment area, to refine both the estimates of 3.5 kg/(ha·yr) or 25 kg/(ha·yr), and the estimate of 25 000 kg/yr.
3. Trowbridge et al. (1999) recorded frequency of plots by age class. More stand age/mushroom productivity data would refine the estimated shape of the pine mushroom yield curve. Work might also characterize yields as a function of tree species and growing site quality.
4. This analysis assumed that harvested stands would produce pine mushrooms at a rate comparable with present natural stands. Researchers have noted that most producing stands indicate fire origin, or volcanic ash deposits. A site may need rough disturbance, and exposure of mineral soil, as a precursor to eventual mushroom productivity. Better understanding of pine mushroom establishment could facilitate increases in production well above current natural levels.
5. This report did not discuss the ancillary benefits of longer forest rotations, including meeting wildlife habitat objectives. A future mushroom and timber supply analysis would incorporate a more detailed breakdown of the forest inventory to use knowledge from points 1 and 3 above, and include the benefits of maintaining increased forest cover.
6. This analysis only considered clearcut harvesting. Preliminary results from partial harvesting trials in British Columbia suggest that considerable timber volume may be removed from a forest with minimal negative impact on mushroom production.
7. Better information should be available about the quality and value of timber in old stands, and the present timber age profile being harvested.
8. This project compared values using total economic return for timber, but only picker revenue for pine mushrooms. A more fair comparison would include the sorting, grading, repackaging, shipping and merchandising economic activity that the mushroom harvest creates.
9. This analysis stopped short of providing an estimate of the "fungage" rate that the government would charge to replace stumpage values potentially foregone by managing forests for both timber and mushrooms. Using the assumptions in the analysis, the fungage rate would be $2/kg, but a subsequent analysis with more refined input data would be needed to accurately develop this value.
10. Accessibility is steadily increasing as remote forest areas are developed. This easier access may increase apparent harvested mushroom volumes over time, until the entire land base is roaded.

11. Other species of wild mushrooms are of increasing commercial value. The economic models used in this project could be adjusted to include yields and returns of species other than the pine mushroom.

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Section E. Extent of potential pine mushroom habitat in the Prince Rupert Forest Region: Two case studies from the Kispiox and Kalum Small Business Forest Enterprise Program

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Methods

Two case studies were undertaken to estimate the extent of pine mushroom habitat, based on the ecological descriptions (Section C), in operable forestry areas of the Prince Rupert Forest Region. The extent and location of pine mushroom habitat will be extremely important in both strategic planning and development plans for areas with timber and mushroom resources.

We used the 5 year development plan for the Kispiox small business forest enterprise program (SBFEP) in the first case study (Table 1). The first two years of the development plan had silviculture prescriptions (SPs) prepared, which detailed soil conditions and site series in each proposed block. The 01b site series was identified in the prescriptions but not mapped out separately from the 01a site series. The proposed cutblocks for the last three years of the development plan were located on maps but no site descriptions had been prepared. For these blocks, we used air photos to identify and quantify the area under 01b site series. Two classes were used depending on how well the area matched the photo signatures from referenced stands[1]: class 1 for well defined 01b, and class 2 for transitional 01b (tending towards 01a but still possible pine mushroom habitat). In the second case study we examined the extent of potential pine mushroom habitat in the Kalum SBFEP of the West Nass, an area highly utilized by commercial mushroom harvesters. For this case study we examined a 7000 ha area along the Harper road and Nass river within the ICHmc1 (see map).

Table 1. Kispiox SBFEP, 5 year development plan by subzone and variant (ha)

	1999	2000	2001	2002	2003	Total	%
ICHmc1	333.9	237.6	205.5	191.3	119.1	1087.4	15.8
ICHmc2	183.4	630.4	512.1	526.0	689.7	2541.6	36.9
ESSF(mc,wv)	702.7	616.8	216.8	443.6	378.7	2358.6	34.2
SBSmc2	135.8	78.3	414.1	165.1	0	793.0	11.5
CWHws2	0	0	0	44.0	66.0	110.0	1.6

RESULTS AND DISCUSSION

Kispiox SBFEP

We found with both methods (SPs and class 1 photo interpretation) that the 01b site series occurred in 15% of the proposed Kispiox SBFEP cutblocks (Table 2). For years 3 to 5 in the development plan, which included forest zones not expected to have commercial harvests of pine mushrooms (the ESSF and SBS), the extent of 01b ranged from 2.25% (class 1 only) to 3.84% (class 1 and 2) of the areas proposed for harvest.

Table 2. Extent of 01b sites series in the Kispiox SBFEP 5 year development plan

Plan year	BEC zone	Assessment	Forest	01b site series		% area
			(ha)	(ha)	Blocks	
Year 1-2	All zones	By SP	2919	n/a	10/66	n/a
	ICH only	By SP	1195	n/a	10/35	n/a
Year 3-5	All zones	By photo 1&2	3963	152.3	23/80	3.84
	All zones	By photo, 1 only	3963	89.1	12/80	2.25
	ICH only	By photo 1&2	2239	152.3	23/44	6.80
	ICH only	By photo, 1 only	2239	89.1	12/44	3.98

Almost 30% of the proposed cutblocks in the ICH, where pine mushrooms can occur, had some 01b habitat identified (by SP or class 1 photo interpretation) (Table 2). In years 3 to 5, the areal extent of the 01b in the ICH zone was almost 4%, or 6.8% if the transitional 01b is included. The relative extent of potential pine mushroom habitat varied between geographic areas because of the variation in landforms found across the ICH. The Helen and Date landscapes, for example, had higher concentrations of 01b ecosystems than the Gail landscape area (Table 3).

Table 3. Relative extent of 01b area (both class 1 & 2) by geographic area for proposed ICH cutblocks

Geographic area	ICH blocks	01b area	Gross area	% 01b
Helen	4	28.2	221.4	12.7
Drumlin-like formations often controlled by bedrock are common to this area. The 01b site series occurs on crest positions of morainal veneers and blankets, and the marginal 01b site series occurs on crest positions and upper convex slopes with a thicker mantle of glacial till.				
Date	6	75.7	499.9	15.1
Bedrock controlled undulating to hummocky terrain of morainal veneers and blankets support the 01b site series, and are found on upper and crest slope positions. The marginal 01b site series are found on morainal blankets overlaying upper convex slopes.				
Muldoe	2	5.6	112.0	5.0
Where glacial fluvial material is expected, the 01b and marginal 01b site series is found in limited areas.				
Gail	24	24.9	990.9	2.5
Generally, a thick blanket of glacial till covers this relatively subdued terrain. Mesic to subhygric stands of balsam and spruce dominate the area and are interspersed with many small wetlands. Marginal 01b sites are found on convex upper slopes, and the few 01b site series are found on ridge crests consisting of morainal veneers.				
Deadhorse	1	4.3	70.9	6.1
The 01b, and marginal 01b site series are found on bedrock controlled, undulating terrain of morainal veneers to blankets.				
Nash Y	3	4.8	134.2	3.6
Glacially eroded, bedrock controlled striations dominate the landscape to form a fluted surface with well to rapidly drained ridge crests supporting the 01b site series.				
Skilokis	1	3.4	90.0	3.7
Steep convex slopes of colluvial material are identified as the marginal 01b site series.				
Sicintine	1	0	59	0
The 01b site series was not identified in this area.				
Kitwancool	1	14.4	113.2	12.7
An undulating mantle of till covers much of the block where upper convex, and moderately steep slopes supports the marginal 01-01b site series. The true 01b site series is found on a steep southwest facing slope of colluvial material.				

Kalum SBFEP

The ICHmc1/01b unit in the west Nass generally occurs on upper slopes and crest positions where bedrock lies close to the surface as rocky “knolls”. These rocky knolls and ridges, composed of shale, are very common and close together, resulting in a very convoluted landscape. The surficial materials are morainal veneers, small colluvial slopes on the sides of the knolls, and *in situ* broken bedrock. A smaller portion of the ICHmc1/01b site series was found to occur on coarse textured glacial fluvial terraces found along the Nass River.

We identified, by air photo interpretation of the study area, a total of 546 separate polygons, ranging in size from 0.3 to 60 ha. We classified 127 of these polygons as class 1, ranging in size from 0.3 to 36 ha, with an average size of 3.5 ha. The extent of ICHmc1/01b site series was 451 ha for class 1, and 1043 ha for class 2. In total (class 1 and 2), an area of 1494 ha, or 21% of the west Nass area examined, was classified as potential pine mushroom habitat.

Stand Age

In addition to soils, a second consideration for pine mushroom potential is stand age. Old-growth stands are thought to produce less mushrooms than mature stands (~50 – 250 years), so the stand ages on the 01b site series would also be an important consideration in forest management. For example, the stand age distribution of the ICHmc2 and mc1 in the Kispiox district shows that much of the mc1 forest is age class 8 (>250 yrs) or older, while the mc2 has a larger extent of younger, mature forests (Figure 1). We as yet do not have specific information of the stand ages across the ICH/01b site series.

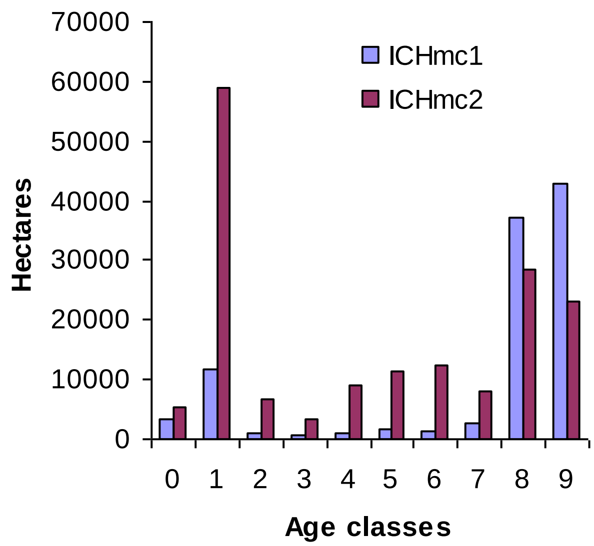

Figure 1. Harvestable forest (ha) by age class in the Kispiox ICH subzones

From these case studies we have demonstrated that pine mushroom habitat can be quite continuous or dispersed, depending on the glacial history and surficial geology of the area. Some areas, such as the Helen, Date and Nass, are valuable to the public because of the relatively high concentration of good mushroom habitat with productive, not overly-mature forests. Even in these valuable areas, the extent of habitat was perhaps 15 to 20% of the forest, which should allow forest managers some opportunities to manage for both timber extraction and pine mushroom harvests.

[1]***Notes regarding air photo interpretation:***

Photo signatures for the 01b site series were referenced from air photos of the confirmed pine mushroom sites described in section C. The ICHmc2/01b site series occurred on upper slope to crest positions with primarily morainal and colluvial veneer surficial materials. The 01b site series was also found infrequently on glacial fluvial terraces. With either of these underlying surficial materials the stand conditions generally looked the same from the air photos. The low productivity of the stands was evident in smaller tree crowns occurring close together, appearing as a smooth, even texture on the air photo. In the transitional 01b sites, indicated by a dotted polygon boundary, the crown closure would tend to be slightly less, giving the stands a more open, coarse-textured appearance. In the 01a site series the coarse textured look of the stand was more pronounced. The stands were dominated by western hemlock.

The ICHmc1/01b site series was slightly different as the presence of lodgepole pine would generally make up 10 to 50 percent of the stand composition. Those 01b sites occurring on glacial fluvial material would often cover a larger area in a given polygon, maintaining a more continuous stand structure across the surface of the terrace. The morainal (and colluvial) material over bedrock had a more undulating pattern, and the 01b site series would generally occupy smaller polygon areas adjacent to depressional subhygric or xeric site series.

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