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BRITISH COLUMBIA

Effects of Alternative Silvicultural Treatments on the Diversity of Forest Fungi in the Roberts Creek Study Forest

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INTRODUCTION

Between 1995 and 1998, the Vancouver Forest Region of the British Columbia Ministry of Forests studied the diversity of mushrooms growing in the Roberts Creek Study Forest on the south coast of British Columbia. Three studies examined how the use of alternative silvicultural systems for timber harvesting affect macrofungus fruiting. This extension note summarizes the results from those studies. The results will assist forest managers in assessing and protecting the ecological diversity of the forest.

STUDY AREA

The Roberts Creek Study Forest was established in the early 1990s to demonstrate, evaluate, and develop silvicultural systems that meet a variety of biological, social, and economic objectives.

Located on the Sunshine Coast about 40 km north of Vancouver, British Columbia, the Roberts Creek Study Forest is in the Pacific Ranges Drier Maritime Coastal Western Hemlock bio-geoclimatic subzone (CWHdm) (Inselberg 1993). Elevation of the research units ranges from 200 to 500 m above sea level, and the site slopes gently to the west. The CWHdm has relatively dry, warm summers and moist, mild winters with little snowfall (Banner et al. 1993).

Douglas-fir (*Pseudotsuga menziesii*) (70%) and western hemlock (*Tsuga heterophylla*) (20%) dominate. The remaining 10% is mostly western redcedar with scattered white pine and alder. The stand is naturally regenerated from fire, and, aside from scattered veterans[3], the dominant trees are between 90 and 130 years old. Timber volume estimates range from 700 to 1200 m^3/ha (Regional Alternative Silvicultural Council Workshop 1995).

Major understory species include salal, red huckleberry, twinflower, sword fern, and a variety of mosses.

TREATMENTS AND HARVESTING

Three distinct harvesting systems and an unharvested control have resulted in a variety of overstory conditions (D'Anjou 1999b). The four treatments were randomly assigned to treatment units ranging from 10 to 12 ha lying within a 1-km^2 area. The **clearcut with reserves** prescription has had all trees and snags, except identified Douglas-fir and western redcedar veterans, removed in a single harvest entry. The two-pass uniform **shelterwood with reserves** prescribed two harvesting entries. The initial harvest, a seed tree cut (spring 1997), reduced the stand density to 70-90 stems/ha (approximately 30% retention) consisting mostly of dominant Douglas-fir and western redcedar. Veterans were retained. Douglas-fir and western redcedar have been inter-planted. The second entry will occur five to ten years after the first entry, and will reduce overstory density to 20 to 30 stems/ha. The **extended rotation** prescription involves five harvesting entries over a 55-year period. The first entry (spring 1996) removed eleven 5-m-wide corridors (approximately 5% of

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[3] Veteran: A mature tree that is considerably older than the trees in the rest of the stand, usually remaining from a previous forest.

the stand). The next two entries, at 15 and 30 years, will each remove 20% of the stand volume. The fourth and fifth entries (at 50 and 55 years) will mimic the shelterwood prescription described above (i.e., reduce the stand first to 70-90 stems/ha, and then to 15-20 stems/ha five years later). An unharvested **control** treatment was permanently set aside from harvesting.

Post-Harvest Stand Structure

Harvesting reduced stand density in the clearcut by over 99%, in the shelterwood by 88%, and in the extended rotation by 14%. Basal area (m^2/ha) was reduced by 98, 71, and 12%, and volume (m^3/ha) was reduced by 99, 69, and 11%, respectively, in the clearcut, shelterwood, and extended rotation plots.

MUSHROOM SAMPLING METHODS

Pre-treatment data were collected in 1995/96. Macrofungi were recorded during reconnaissance surveys and mushroom forays, and on permanent sampling plots. Reconnaissance surveys were undertaken between August and November 1995, mushroom forays occurred on two weekends in September and October 1995, and sampling on permanent plots occurred from November 1995 to March 1996.

During harvest, data were collected on the types of macrofungi found throughout the study area from September 1996 to January 1997.

Post-harvest data were collected in spring 1997. From the preliminary species list, 120 species were selected for study, including 59 saprophytic, 6 parasite, and 55 mycorrhizal fungi. These covered a range of ecological roles (see Appendix A), including many well-known edible and medicinal mushrooms and some sensitive, uncommon, obscure, or otherwise interesting fungi. Some of these, such as the pine mushroom (*Tricholoma magnivelare*) and chanterelles (*Cantharellus* sp.), represent potential 'indicator' species because of their ecological and economic importance. Others are of traditional or cultural importance to First Nations people. Three species of slime mold (*Fulgio septica, Leocarpus fragilis,* and *Lycogala epidendrum*) were also included.

Although some mushroom sampling occurred in spring and summer, most sampling was performed between September and December 1997. In order to ensure broad coverage, the 10-12-ha treatments were sub-divided into three areas: east, mid, and west portions (approximately 3-4 ha each) which were visited on successive field days. Presence of mushrooms, fruit bodies, or sporocarps of the selected species in each treatment area and the control was recorded during walk-through reconnaissance surveys. Specimens of some species were collected for further examination and dried for reference purposes. Macrofungi were identified using the mushroom field guides, texts, literature, and fungal keys cited at the end of this report. For each treatment area and the control, macrofungal species sub-lists of the types and number of species recorded in each ecological niche were created.

RESULTS

Prior to harvesting, over 150 mushroom species were recorded as being present in the study area. While timber harvesting was underway, 358 types (including slime molds) were identified.

Macrofungal Fruiting After Timber Harvesting

In the control, 115 of the 120 species selected for study were found fruiting (55 saprophytic, 6 parasitic, and 54 mycorrhizal) (Table 1). In the extended rotation, 101 of the species were recorded (49 saprophytic, 4 parasitic, and 48 mycorrhizal). In the shelterwood, 83 of the selected species (41 saprophytic, 5 parasitic, and 37 mycorrhizal) were encountered, while in the clearcut only 39 were recorded fruiting (34 saprophytic, 1 parasitic, and 4 mycorrhizal).

Control: Approximately 96% of the selected species were recorded fruiting. Of these, approximately half were biotrophic (mycorrhizal or parasitic) and half were saprophytic. Eight species (*Cantharellus subalbidus, Chroogomphus tomentosus, Clavaria purpurea, Gomphus clavatus, Hydnellum caeruleum, Hygrophoropsis aurantiaca, Hypomyces lactifluorum*, and *Ramaria stricta*) were encountered only in the control. Of the mycorrhizal species, only *Gomphus floccosus* was not recorded in the control.

Extended rotation: Approximately 84% of the selected species were encountered and again approximately half of these were biotrophs while the other half were saprophytes. One species, *Clavaria vermicularis*, was recorded only in the extended rotation.

Shelterwood: About 70% of the selected species were found fruiting; again, about half were biotrohic and half were saprophytic. One species, *Gomphus floccosus*, was encountered only in the shelterwood.

Clearcut: Approximately 33% of the selected species were recorded, of which nearly 90% were saprophytes. Four mycorrhizal fungi (*Amanita porphyria, Laccaria laccata, Lactarius*

Table 1. Number of selected mushroom species recorded fruiting: post-harvest results, by treatment.

Species type	Treatment: silvicultural system			
	Control (no.)	Extended rotation (no.)	Shelterwood (no.)	Clearcut (no.)
Parasitic	6	4	5	1
Mychorrhizal	54	48	37	4
Saprophytic	55	49	41	34
Total	115	101	83	39

affinis, and *Tricholoma sejunctum*) were found fruiting either near standing residual (reserve) trees or, in the case of *L. affinis*, on the edge of the clearcut adjacent to the control. *Pholiota limonella and Gloephyllum saepiarium*, both saprophytes, were encountered only in the clearcut.

Some General Trends

The control had the greatest number of macrofungus species, followed by the extended rotation, shelterwood, and finally the clearcut. This seems to correlate with the post-harvest stand attributes because the stems/ha, basal area, and volume were all greatest in the control, followed by the extended rotation, shelterwood, and the clearcut.

Only 31 species, the majority saprophytic, were recorded in all three treatments plus the control. The saprophyte, *Gloephyllum saepiarium*, was found in all three treatments but not in the control. Forty-four species, the majority mycorrhizal, were found only in the the units where some or all trees were retained—i.e., extended rotation, shelterwood, and control—but not in the clearcut. Twenty-one species, again mostly mycorrhizal ones, were recorded in the control and extended rotation, but not in the clearcut or shelterwood.

CONCLUSIONS

Three studies examined how the use of alternative silvicultural systems for timber harvesting affect mushroom diversity and macrofungus fruiting. The study took place between 1995 and 1998 in the Roberts Creek Study Forest on the south coast of British Columbia.

This study, the first of its kind in British Columbia, has generated significant information regarding the short-term effects of partial harvesting on macrofungal fruiting. The results of this study are consistent with results of other similar studies (e.g., Kranabetter 1997), and these studies also showed a first-year post-harvest correlation between reduced stand density and reduced mushroom diversity. However, replication, baseline sampling, and a number of years of post-harvest sampling are required in order to reach conclusions about the longer-term effects.

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APPENDIX A

Presence of selected species of macrofungi and slime molds in alternative silvicultural treatment units, post-harvest results.

Latin name	Common name	Ecological role or niche [a]	Treatment: silvicultural system			
			Control	Extended rotation	Shelterwood	Clearcut
Aleuria aurantia	Orange peel fungus	S	+	+	+	+
Amanita porphyria	Purple brown amanita	M	+	+	+	+[b]
Amanita silvicola	Woodland amanita	M	+	+	+	
Amanita smithiana	Smith's amanita	M	+	+	+	
Armillaria mellea	Honey mushroom	P	+	+	+	+
Auricularia auricula	Tree (wood) ear	S	+	+		
Boletopsis leucomelaena	Kurotake	M	+	+		
Boletus mirabilis	Velvet top	M	+	+	+	
Caloscypha fulgens	Blue staining cup	S				+
Camarophyllus graveolens	Moth balls	M?	+	+	+	
Cantharellus cibarius	Chanterelle	M	+	+	+	
Cantharellus infundibuliformis	Funnel chanterelle	M	+	+	+	
Cantharellus subalbidus	White chanterelle	M	+			
Chroogomphus tomentosus	Woolly gomphidius	M	+			
Clavaria purpurea	Purple club coral	S	+			
Clavaria vermicularis	White club coral	S		+		
Clavulina cristata	Crested coral	S	+	+	+	+[b]
Collybia acervata	Clustered collybia	S	+	+	+	
Coltricia cinnamomea	Cinnamon polypore	S	+	+	+	+[b]
Cortinarius cinnamomeo-luteus	Cinnamon cort	M	+	+		
Cortinarius corrugis	Corrugated top	M	+	+	+	
Cortinarius cotoneus	Electric motor cort (dark)	M	+	+	+	
Cortinarius phoeniceus	Red capped cort	M	+	+	+	
Cortinarius semisanguineus	Red gilled cort	M	+	+	+	
Cortinarius traganus	Pungent cort (pear smell)	M	+	+		
Cystoderma amianthinum	Pure cystoderma	S	+	+	+	
Dacrymyces palmatus	Orange jelly	S	+	+	+	+
Entoloma lividum	Livid entoloma	S	+	+	+	+
Fomes pini	Pine conk	P	+	+	+	
Fomitopsis cajanderi	Rosy polypore	S	+	+	+	
Fomitopsis pinicola	Red belt	S	+	+	+	+
Fuligo septica	Scrambled egg slime	S	+	+	+	+
Ganoderma applanatum	Artists conk	S	+	+	+	+

Appendix A, continued:

Latin name	Common name	Ecological role or niche [a]	Treatment: silvicultural system			
			Control	Extended rotation	Shelterwood	Clearcut
Gloeophyllum saepiarium	Gilled polypore	S		+	+	+
Gomphidius subroseus	Rosy gomphidius	M	+	+	+	
Gomphus clavatus	Pigs ear gomphus	M	+			
Gomphus floccosus	Woolly chanterelle	M			+	
Guepiniopsis alpinus	Golden jelly cone	S	+	+	+	+
Gyromitra esculenta	False morel	S	+		+	
Helvella lacunosa	Elfin saddle	S	+	+	+	
Hydnellum aurantiacum	Orange hydnellum	M	+	+	+	
Hydnellum caeruleum	Blue-grey tooth/orange flesh	M	+			
Hydnellum peckii	Strawberries and cream	M	+	+		
Hydnum fusco-indicum	Violet hedgehog	M	+	+		
Hydnum repandum	Spreading hedgehog	M	+	+	+	
Hydnum umbilicatum	Smaller hedgehog	M	+	+		
Hygrophoropsis aurantiaca	False chanterelle	S	+			
Hygrophoropsis olida	Bubblegum fungus	M?	+		+	
Hygrophorus bakerensis	Almond scented hygro-phorus	M	+	+		
Hygrophorus camarophyllus	Sooty brown waxy cap	M	+	+	+	
Hygrophorus conicus	Witches hat	M?	+	+		
Hygrophorus eburneus	White waxy cap	M	+	+	+	
Hygrophorus pratensis	Salmon waxy cap	M	+	+	+	
Hypholoma campnoides	Smoky gilled wood lover	S	+	+	+	+
Hypholoma fasciculare	Clustered wood lover	S	+	+	+	+
Hypomyces hyalinus	White parasite	P	+	+	+	
Hypomyces lactifluorum	Lobster mushroom	P	+			
Inocybe calamistrata	Green-footed fibre head	M	+	+		
Laccaria amethysteo-occidentalis	Purple laccaria	M	+	+	+	
Laccaria laccata	Common laccaria	M	+	+	+	+[b]
Lactarius affinis	Tan milky cap/hollow stem	M	+	+	+	+[b]
Lactarius deliciosus	Delicious milky cap	M	+	+	+	
Lactarius kaufmanii	Large grey milky cap	M	+	+	+	
Lactarius pseudomucidus	Slimy milky cap	M	+	+	+	
Lactarius rubrilacteus	Red juiced milky cap	M	+	+	+	
Lactarius rufus	Red milky cap	M	+	+		

Appendix A, continued:

Latin name	Common name	Ecological role or niche [a]	Treatment: silvicultural system			
			Control	Extended rotation	Shelterwood	Clearcut
Lactarius scrobiculatus	Spotted milky cap	M	+	+	+	
Laetiporus sulfureus	Sulphur shelf	S	+		+	
Leocarpus fragilis	Insect egg slime	S	+	+	+	
Lycogala epidendrum	Wolf's milk slime	S	+		+	
Lycoperdon perlatum	Studded puffball	S	+	+	+	
Lycoperdon pyriforme	Pear-shaped puffball	S	+	+	+	+
Lyophyllum descastes	Fried chicken mushroom	M	+	+		
Marasmius copelandi	Garlic mushroom	S	+	+	+	
Mycena alcalina	Bleach mycena	S	+	+	+	+
Mycena epipterygia	Yellow stalked mycena	S	+	+	+	+
Mycena galericulata	Common mycena	S	+	+	+	+
Mycena haematopus	Bleeding mycena	S	+	+	+	+
Mycena pura	Pure mycena	S	+	+	+	+
Mycena purpureofusca	Purple gill edged mycena	S	+	+		+
Mycena strobilinoides	Red-orange mycena	S	+	+	+	+
Mycena subcana	Grey mycena	S	+	+	+	+
Omphalina ericitorem	Lichen agaric	S	+	+	+	+
Otidea leporina	Rabbit ears	S	+	+	+	
Panellus serotinus	Winter (late) oyster	S	+	+		+
Paxillus atrotomentosus	Velvet foot pax	S	+	+	+	+
Phaeolus schweinitzii	Dye polypore	P	+	+	+	
Pholiota limonella	Golden pholiota	S				+
Phylloporus rhodoxanthus	Gilled bolete	S	+	+	+	
Pleurocybella porrigens	Angel wings	S	+	+		
Pleurotus ostreatus	Oyster mushroom	S	+	+		+
Pluteus cervinus	Deer mushroom	S	+	+		
Polyozellus multiplex	Blue chanterelle	M	+		+	
Polyporus elegans	Black foot polypore	S	+	+	+	+
Pseudohydnum gelatinosum	White jelly	S	+	+		
Ramaria cystidiophora	Yellow (lemon) ramaria	S	+	+	+	
Ramaria gelatiniaurantia	Orange jelly belly coral	S	+	+		
Ramaria gelatinosa	Jelly based coral	S	+	+		
Ramaria stricta	Straight branched coral	S	+			

Appendix A, continued:

Latin name	Common name	Ecological role or niche [a]	Treatment: silvicultural system			
			Control	Extended rotation	Shelterwood	Clearcut
Rozites caperata	Gypsy mushroom	M?	+	+	+	
Russula aeruginea	Green russula	M	+	+		
Russula brevipes	Short-stemmed russula	M	+	+		
Russula cascadensis	Acrid russula	M	+	+	+	
Russula xerampelina	Shrimp mushroom	M	+	+	+	
Schizophyllum commune	Split gill	S	+	+	+	+
Sparassis crispa	Cauliflower fungus	P	+		+	
Stereum complicatum	Crowded parchment	S	+	+	+	+
Strobillurus trullisatus	Fir-cone mushroom	S	+	+	+	+
Suillus granulatus	Dotted stalk slippery jack	M	+	+	+	
Suillus lakei	Lake's bolete	M	+	+	+	
Suillus subolivaceous	Olive cupped bolete	M	+	+		
Trametes versicolor	Turkey tail	S	+	+	+	+
Tremella lutescens	Witches butter	S	+			+
Tricholoma flavovirens	Man-on-horseback	M	+	+	+	
Tricholoma magnivelare	Pine mushroom	M	+	+	+	
Tricholoma sejunctum	Separating trich	M	+	+	+	+[b]
Tricholoma zelleri	Zeller's trich	M	+	+	+	
Tricholomopsis decora	Yellow rotter	S	+	+		
Xeromphalina cauticinalis	Small orange/brown cap	S	+	+	+	
Xylaria hypoxylon	Carbon antlers	S	+			+

[a] *M = mycorrhizal. S = saprophytic. P = parasitic.*
[b] *Encountered near veteran or residual (reserve) tree in the clearcut.*

NOTES