

Occupational Exposure to Chemical, Biological, and Physical Agents in Ontario Sawmill and Veneer / Plywood Plants

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TABLE OF CONTENTS

	PAGE
ABSTRACT	1
PLAIN LANGUAGE SUMMARY	2-3
LIST OF TABLES	4-5
LIST OF FIGURES	6
LIST OF APPENDICES	6
1. INTRODUCTION	7-8
2. OVERVIEW OF FORESTRY IN CANADA	9-10
2.1 Softwood vs Hardwood	10
2.2 Forests of Ontario	10-14
3. EXPOSURE STANDARDS AND LIMITS	15
3.1 Wood Dust	15-17
3.2 Noise	18
3.3 Biological Agents	18
4. BRIEF REVIEW OF RELEVANT RESEARCH	19
4.1 Wood Dust – Particulates and Mould	19-24
4.2 Formaldehyde	24-25
4.3 Terpenes	25-26
4.4 Chlorophenates	26-27
4.5 Noise and Other Exposure	27-28
4.6 Summary	28
5. RESEARCH OBJECTIVES	29
5.1 Specific Goals	29
6. METHODS	30
6.1 Questionnaire Survey	30
6.2 Observational (Walk-thru) Survey	30-31
6.2.1 Wood Dust	32
6.2.2 Noise	32
6.2.3 Biological Agents	32
6.2.4 Other Potential Exposure	32
7. RESULTS	33
7.1 Questionnaire Survey	33-34
7.1.1 Industry Characteristics	34-35
7.1.2 Hazards	36-39
7.2 Observational (Walk-thru) Survey	39-89
8. DISCUSSION	90-95
9. CONCLUSIONS	96
10. RECOMMENDATION FOR FUTURE WORK	97
11. PLANS FOR DISSEMINATION OF RESEARCH FINDINGS	97
12. ACKNOWLEDGEMENTS	97
13. REFERENCES	98-102

ABSTRACT

OBJECTIVES: The main objective of this small scale feasibility study is to determine whether a full two year study involving extensive sampling of airborne chemical, biological and physical agents is reasonable to provide data for health study and direction for future initiatives in this industry.

METHODS: The research procedure was focused on information gathering through two primary means – questionnaires and observational (walk-thru) surveys. During the walk-thru surveys only wood dust, noise and limited biological agents were measured.

RESULTS: 35 firms responded to the questionnaires. The results of the walk-thru surveys at 22 different sites from 17 different companies for dust ,noise and biological agents are given in Tables 12 (a and b) to Table 33(a and b).

CONCLUSIONS: Consistent historical health status (medical) records are not available at the various companies in this industry for an industry wide epidemiological dose response health study to be conducted. Historical wood dust data is also scarce. The results indicate that the wood dust exposures in this industry are likely to be mostly below the current Ontario occupational exposure limit of 5 mg/m³ as total dust. A comprehensive industry wide wood dust, noise and biological agents exposure study should be conducted.

PLAIN LANGUAGE SUMMARY

OBJECTIVES: The main objective of this small scale “feasibility study” was to determine whether a full two year study involving extensive sampling of airborne chemical, biological and physical agents in sawmills (2000 WSIB rate group 033) and veneer mills (2002 WSIB rate group 036) is reasonable to provide data for an industry-wide health study (e.g. epidemiological dose-response study) and directions for future initiatives in this industry.

METHODS: Two primary research methods were used in the study – (1) Questionnaires Survey and Observational (walk-thru) Survey. Separate questionnaires were sent to selected groups including safety managers; small business operators; health and safety representative; and joint health and safety committee representatives to gather information on workplace characteristics, demographics, health and safety practices, and opinions regarding occupational health and safety practices.

Observational (walk-thru) onsite surveys were conducted by two investigators following the questionnaire survey to assess in a preliminary way prevailing occupational health hazards, consult with site-staff about occupational health and safety issues and problems, validate responses to the questionnaire, conduct preliminary measurements of dust, noise and mould and take note of other potential hazardous exposure to other contaminants.

RESULTS: 35 firms responded to the questionnaire; another 18 firms declined to complete the survey. One was returned and one reported no longer being in the business. Half of the firms completing the survey reported employing 100 or more workers. The smallest number of workers reported by a responding firm was two. Less than 10% of the firms with 5 or less workers responded to the questionnaire survey.

Approximately 55% softwood and 45% hardwood are processed in the industry. Two or three work shifts are common. On average 19% of the workers employed in the industry are under 25 years of age; 64% of workers are between 25 - 49 years old, 17% are 50 years and older. With respect to years of service, 17% of the workforce on average had worked for less than 2 years with their current employer, 21% had 2-5 years of service, and 62% had worked for more than 5 years for the same employer.

The responses to the questions regarding existence of occupational health hazards indicated that most employers and employees were aware of health hazards due to exposure to wood dust, noise and mould. Both employers and employees were aware of hazard control and personal protective devices.

The result of the work-thru surveys at 22 different sites from 17 different companies for wood dust, noise and moulds shows exposure levels to be similar to what is reported in this industry in Canada and elsewhere. Airborne wood dust exposure measured ranged between 0.002mg/m³ to 2.8 mg/m³ as total dust. Noise exposure ranged between 55 to 106 dB(A).

Also, during the walk-thru surveys, information obtained from the questionnaire was validated and information about availability of health records of the employees was sought. Availability of health records is required for any health study (epidemiological dose response study).

CONCLUSIONS: It appears that the consistent health status (medical) record going back in time to present day is not available at the various companies and therefore an industry wide health study (epidemiological dose-response study) will likely not be possible. Such a study may be possible if limited to a few large companies who may have the required data. Historical occupational exposure data of chemicals (e.g. wood dust) for any epidemiological dose-response study will require reconstruction of past exposure and retrospective exposure assessment.

This “feasibility study” used instantaneous direct reading instruments to get an idea of range of exposures. It would appear that wood dust exposures are likely mostly below the current Ontario occupational exposure limit of 5 mg/m³ as total dust. This, however, needs to be confirmed by long term sampling. Noise exposure at many locations are above the current and the proposed (effective as of July 2007) occupational exposure limits. Exposure to biological agents (mould and fungi) at some locations is of concern.

A comprehensive industry wide wood dust exposure study involving statistically significant numbers of both personal and area samples of both inhalable and total dusts should be conducted. Such an exposure assessment study is recommended since it would be very useful now and for future assessment of exposures in this important industry. Exposures to noise and biological agents (fungi and bacteria) are also worthy of consideration for assessment.

LIST OF TABLES

TABLE #	TITLE	PAGE#
1	Canadian Forest Product Exports	9
2	Ontario Hardwood and Softwood Trees and Uses	13-14
3	ACGIH's TLV Chronology of Wood Dust	16
4	Available Provincial Wood Dust Standards (measured as total dust)	17
5	Conversions based on ratio 2.5 of inhalable/total dust	17
6	Current Ontario Noise Regulation	18
7	Questionnaire Respondents (based on firm size)	33
8	Available Occupational Health Programs	36
9	Perceived Hazards in the Workplace (Comparison of Employers n=35)	38
10	Mean Perceptions of Health Risks with Respect to Health & Safety Representatives and Joint Health & Safety Worker or Management Representatives	38
11	Overall Priority Rating for Occupational Health	39
12(a)	Site 01 — Noise and Dust Data of a Sawmill	40
13(a)	Site 02 — Noise and Dust Data of a Plywood/Particleboard Plant	41
13(b)	Site 02 — Biotest Data of a Plywood/Particleboard Plant	42
14(a)	Site 03 — Noise and Dust Data of a Veneer Plant	43
14(b)	Site 03 — Biotest Data of a of a Veneer Plant	44
15(a)	Site 04 — Noise and Dust Data of a Sawmill	45
15(b)	Site 04 — Biotest Data of a Sawmill	46
16(a)	Site 05 — Noise and Dust Data of a Sawmill/Planer Mill	47
16(b)	Site 05 — Biotest Data of a Sawmill/Planer Mill	48
17(a)	Site 06 — Noise and Dust Data of a Scrag Mill	49
17(b)	Site 06 — Biotest Data of a Scrag Mill	50
18(a)	Site 07 — Noise and Dust Data of a Log Mill	51
18(b)	Site 07 — Biotest Data of a Log Mill	52
19(a)	Site 08 — Noise and Dust Data of a Scrag Mill	53
19(b)	Site 08 — Biotest Data of a Scrag Mill	54
20(a)	Site 09 — Noise and Dust Data of a Log Mill	55
20(b)	Site 09 — Biotest Data of a Log Mill	56
21(a)	Site 10 — Noise and Dust Data of a Sawmill/Planer Mill	57
22(a)	Site 11 — Noise and Dust Data of a Sawmill	58
23(a)	Site 12 — Noise and Dust Data of a Band Mill	59
23(b)	Site 12 — Biotest Data of a Band Mill	60
24(a)	Site 13 — Noise and Dust Data of a Scrag Mill	61
24(b)	Site 13 — Biotest Data of a Scrag Mill	62
25(a)	Site 14 — Noise and Dust Data of a Planer Mill	63
26(a)	Site 15 — Noise and Dust Data of a Plywood Plant	64
26(b)	Site 15 — Biotest Data of a Plywood Plant	65
27(a)	Site 16 — Noise and Dust Data of a Planer Mill	66
27(b)	Site 16 — Biotest Data of a Planer Mill	67
28(a)	Site 17 — Noise and Dust Data of a Sawmill/Planer Mill	68

TABLE #	TITLE	PAGE#
28(b)	Site 17 — Biotest Data of a Sawmill/Planer Mill	69
29(a)	Site 18 — Noise and Dust Data of a Sawmill	70
29(b)	Site 18 — Biotest Data of a Sawmill	71
30(a)	Site 19 — Noise and Dust Data of a Flooring Plant	72
30(b)	Site 19 — Biotest Data of a Flooring Plant	73
31(a)	Site 20 — Noise and Dust Data of a Sawmill/Planer Mill	74
31(b)	Site 20 — Biotest Data of a Sawmill/Planer Mill	75
32(a)	Site 21 — Noise and Dust Data of a Sawmill	76
32(b)	Site 21 — Biotest Data of a Sawmill	77
33(a)	Site 22 — Noise and Dust Data of a Sawmill/Planer Mill	78
34	Meeting Room – Compiled Data of the 22 Sites	79
35	Outdoors – Compiled Data of the 22 Sites	79
36	Log Yard – Compiled Data of the 22 Sites	80
37	Steam Room – Compiled Data of the 22 Sites	80
38	Bailer – Compiled Data of the 22 Sites	80
39	Debarker – Compiled Data of the 22 Sites	81
40	Edger – Compiled Data of the 22 Sites	82
41	Trimmer – Compiled Data of the 22 Sites	83
42	Chipper – Compiled Data of the 22 Sites	84
43	Headrig/Sawyer/Band Saw – Compiled Data of the 22 Sites	85
44	Resaw – Compiled Data of the 22 Sites	86
45	Planer – Compiled Data of the 22 Sites	86
46	Slasher – Compiled Data of the 22 Sites	87
47	Veneer Plant – Compiled Data of the 22 Sites	87
48	Grading – Compiled Data of the 22 Sites	88
49	Boardway/Green Chain – Compiled Data of the 22 Sites	88
50	Filing Room – Compiled Data of the 22 Sites	88
51(a)	Summary Table of Similar Locations of the 22 Sites Values sorted based on Noise Median Low to High	89
51(b)	Summary Table of Similar Locations of the 22 Sites Values sorted based on Dust Mean Low to High	89

LIST OF FIGURES

FIGURE #	TITLE	PAGE #
1	Canadian Forest Land Ownership	9
2	Canada's Forest Types	10
3	Ontario Forest Regions	11
4	Percentage of Ontario's Forests (Regions)	12
5	Percentage of Ontario's Forests (Wood Type)	12
6	Dust, Noise and Biological Sampling Equipment	31
7	Graph of Questionnaire Respondents (based on firm size)	34
8	Distribution of Wood Species Being Processed in the Industry	35
9	Age Distribution of the Workforce in the Sawmill Plywood/Veneer Industry	35
10	Years of Service for Sawmill Plywood/Veneer Industry Workforce	35
11	Cleanup Methods	37

APPENDIX

LETTERS
APRIL 11, 2003 – INITIAL LETTER SENT
MAY 12, 2003 – FOLLOW-UP LETTER SENT
DISTRIBUTED QUESTIONNAIRES
Health and Safety Manager, Plant Manager, or Owner (Part1)
Joint Occupational Health and Safety Worker Co-chair (Part2)
Joint Occupational Health and Safety Management Co-chair (Part2)
Health and Safety Representative (Part2)

1. INTRODUCTION:

By products of wood processing, such as wood dust, mould, formaldehyde, and noise are well known with respect to their health effects. Research on occupational exposures in sawmill and related industries in other jurisdictions has suggested that workers in sawmills, lumber mills, plywood and particleboard factories, and veneer plants are at risk of developing allergenic disorders, cancer, and lung disease.

McMaster University, in partnership with the Ontario Forestry Safe Workplace Association (OFSWA), conducted a pilot study to evaluate the feasibility of assessing industrial and environmental chemical, physical and biological hazards specific to the Ontario's sawmills, plywood/veneer plants and primary wood manufacturing industries. Investigators visited various workplaces representative of the industry in order to assess environmental conditions and work practices, evaluate exposure controls, and conduct a limited air sampling campaign. In the process, researchers consulted with employers, workers and joint occupational health and safety committee members on relevant issues and concerns. The research program included a questionnaire survey of exposure conditions, hazard awareness, and health perceptions, and on-site surveys.

According to current OFSWA data, there are 363 sawmills and 71 veneer/plywood plants in Ontario employing approximately 15,000 workers. About 80% of the firms employ less than 20 workers. The occupational health risk faced by the workers of the smaller firms may be different than the larger firms. By the very nature, forestry is an industrial activity that tends to occur in remote and isolated locations (logging), or in rural areas and near small villages and towns (sawmills, veneer/plywood and other board manufacturing plants). The occupational exposures faced by this group of Ontario workers have not been studied to any significant extent. Several studies have been reported in the literature from other countries and also from other provinces in Canada (most notably BC and Eastern Quebec). Our search for published studies involving Ontario sawmills and veneer plants yielded only one study, which was conducted to address the issue of dermatitis in a particleboard manufacturing facility [Saary et al., 2001]. Although there have been reports of a study designed to investigate pulmonary function, respiratory symptoms and nasal cancer along with measurements of exposure to wood dust and formaldehyde in four cabinet making companies in Toronto [Holness et al., 1985; Sass-Kortsak et al., 1986], reports on occupational exposures in sawmills and veneer plants in Ontario are largely non-existent. There is therefore, a definite and pressing need to study the occupational exposures to chemical, biological and physical hazards and their resultant health effects among this group of workers.

The American Conference of Governmental Industrial Hygienists in the 2005 Threshold Limit Values for Chemical Substances and Physical Agents [ACGIH, 2005] classified Western Red Cedar as a sensitizer and certain hardwoods as confirmed human carcinogens (A1). IARC has classified wood dust as carcinogenic to humans (Group 1)[IARC, 1995b]. Formaldehyde, a common agent found in adhesives used in

oriented-strandboard (chipwood) plants, is listed by ACGIH as a suspected human carcinogen (A2) [ACGIH, 2005] and sensitizer, and by IARC as probably carcinogenic to humans (Group 2A) [IARC, 1995a]. Pentachlorophenol, commonly found in fungicides is classified by ACGIH as a confirmed animal carcinogen with unknown relevance to humans (A3) [ACGIH, 2005] and by IARC as possibly carcinogenic to humans (2B)[IARC, 1991]. However, IARC has gone further to classify lumber and sawmills (including logging) as unclassifiable as to carcinogenicity in humans (Group 3) [IARC, 1987]. The WSIB RAC expressed interest in occupational cancer and mechanisms of causation of occupational disease. This project identified those operations or trades among which increased risk of cancer and other diseases are likely, so that these sectors can be targeted for prevention programs. Many studies have made note of the health effect of moulds and other fungi on lung function of forestry workers. It should be realized that studies conducted in other jurisdictions may or may not be applicable to Ontario. For example, studies in British Columbia primarily dealt with softwood, while in Ontario hardwood is more prevalent due to the existence of the deciduous forest in the St. Lawrence Lowlands. As a result, the associated workplace contaminants and their adverse health impacts may be different. Studies are needed that specifically address the needs of Ontario sawmill and plywood/veneer plant workers.

The purpose of this small scale feasibility study was to determine whether a full-study of two years involving extensive sampling of airborne contaminants would be reasonable to provide data for a health study and recommendations for future initiatives in this industry with the aim of preventing unnecessary occupational exposure to chemical agents (i.e. wood dust), biological agents (i.e. mould and bacteria) and physical agents (i.e. noise). A code of safe work practice could be developed from this information. Epidemiological studies of exposure and health effects could also be postulated.

2. OVERVIEW OF FORESTRY IN CANADA

Canadian forests are an invaluable natural resource. The logging industry harvests about 0.3% of the trees for domestic and international markets. The forest industry plays an important role for the Canadian economy. In 2004, the value of forest products exported was \$44.6 billion with British Columbia, Quebec and Ontario being the top 3 provinces playing key rolls in this area (see Table 1). The majority of the forested land in Canada is governmentally controlled (see Figure 1). The Canadian forests are made up of softwood, hardwood and mixed wood forests but the majority is softwood (see Figure 2).

Table 1: Canadian Forest Product Exports

Source: [Natural Resources Canada, 2005]

Canada Total Exports (2004) – \$44.6 billion		
Province	2004 Exports (\$ billions)	% Total
BC	14.7	33.0
QB	11.9	26.7
ON	9	20.2
AB	3.4	7.6
NB	2.5	5.6
NS	1	2.2
SK	0.8	1.8
MB	0.7	1.7
NF	0.5	1.2

Figure 1: Canadian Forest Land Ownership

Source: [Natural Resources Canada, 2005]

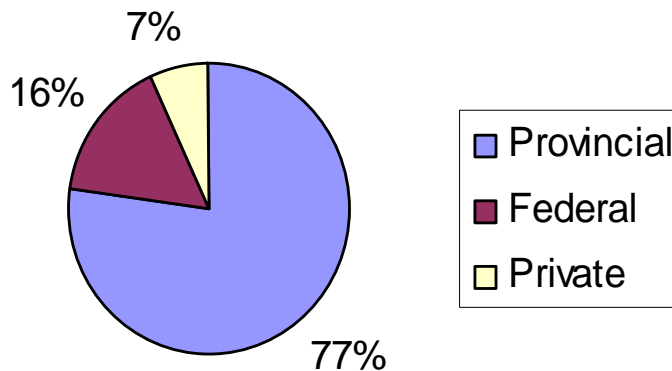
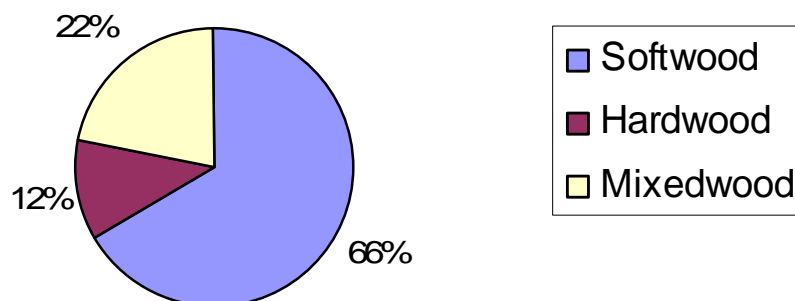


Figure 2: Canada's Forest Types

Source: [Natural Resources Canada, 2005]



2.1 SOFTWOOD VS HARDWOOD

In general, softwoods tend to be easier to cut than hardwoods. The term hardwood, however, does not necessarily imply a harder and denser wood than softwood. For example, balsa wood is one of the lightest, least dense woods but it is classified as a hardwood. Essentially, the difference between these two types has to do with their reproduction. All trees reproduce by producing seeds. Hardwoods (classified botanically as angiosperms) produce seeds with some sort of covering which might be as fruit or as hard shells such as acorns. Softwoods (classified botanically as gymnosperms) have seeds that fall to the ground with no covering such as seeds in cones. These seeds are released by the wind once they mature and are spread out over a wide area. Hardwoods are also referred to as deciduous trees and softwood as coniferous.

2.2 FORESTS OF ONTARIO

Ontario has four forest regions. They are the Boreal Forest, the Boreal Barrens Forest (also referred as Hudson Bay Lowlands), the Great Lakes-St. Lawrence Forest and the Deciduous Forest (see Figure 3). The Boreal Forest region makes up the largest area with 59% of Ontario's forests (see Figure 4). Figure 5 indicates Ontario forests are comprised with 58% being of softwood, 16% hardwood and 26% of mixed woods. British Columbia is comprised of 82% softwood, 5% hardwood and 13% mixed woods and Quebec's forests are of 73% softwood, 11% hardwood and 16% mixed woods. Table 2 indicates Ontario hardwood and softwood trees and uses.

Figure 3: Ontario Forest Regions

SOURCE: [ENVIRONMENT CANADA, 2006]

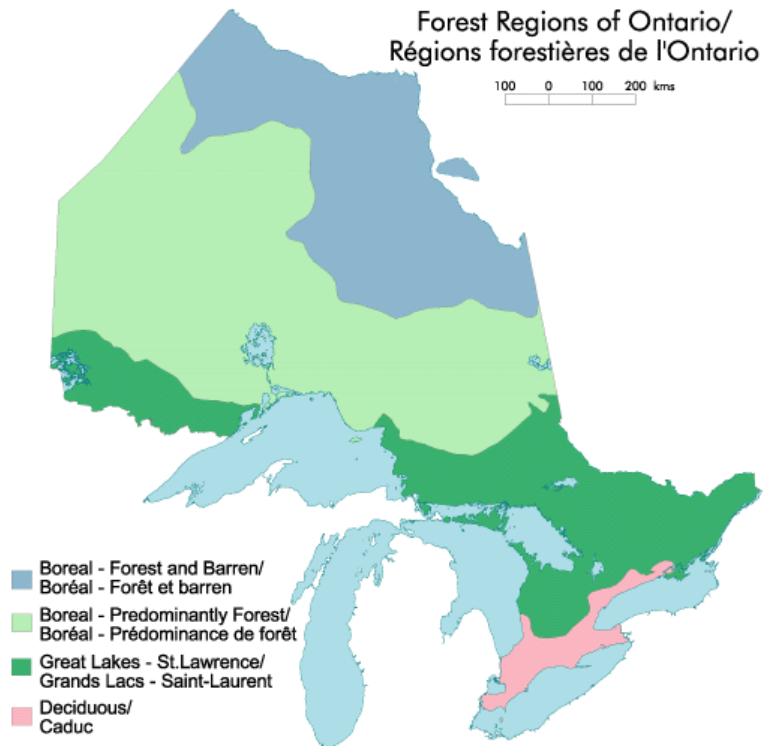


Figure 4: Percentage of Ontario's Forests (Regions)

Source: [Ontario Ministry of Natural Resources, 2002]

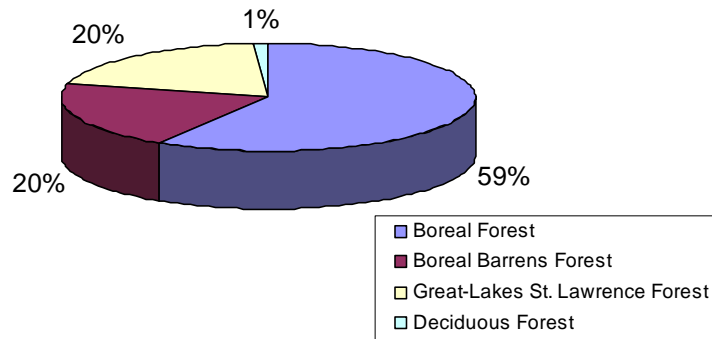


Figure 5: Percentage of Ontario's Forests (Wood Type)

Source: [Natural Resources Canada, 2005]

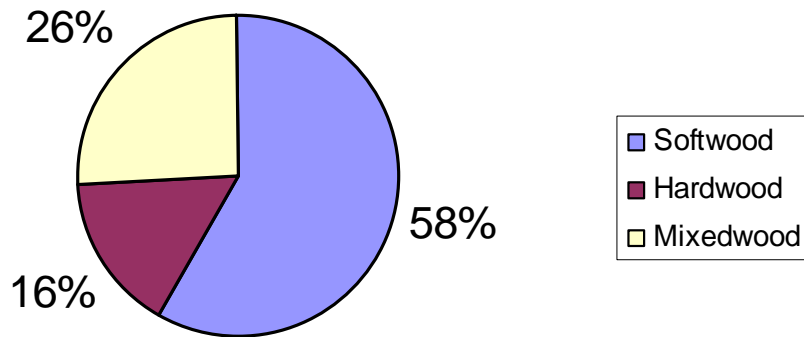


Table 2: Ontario Hardwood and Softwood Trees and Uses

Source:[OFSWA, 2001]

Tree Species	Type	Information	Use
<u>Deciduous (HARDWOOD)</u>			
Ash	black ash	med-hard, coarse grain	furniture, cabinetry, interior finishing (not as commercially useful as white ash)
	red ash		furniture, sporting goods, agricultural tools (marketed commercially as white ash)
	white ash		sporting goods, handles, furniture, agricultural tools
Birches	white birch	moderately hard and strong	veneer stock, pulpwood, special products, turnery
	yellow birch	heavy, hard and strong	veneer, plywood, furniture, cabinet work, interior trim, flooring, doors
Maple	Manitoba maple		boxes, rough construction, firewood
	red maple		furniture, veneer, plywood, boxes & crates (not valued as timber)
	silver maple		pulpwood, furniture, flooring, boxes & crates
	sugar maple	common hardwood	furniture, flooring, farm tools, veneer, plywood, dies & cutting blocks (important hardwood of Canada)
Oak	burr oak		furniture, interior finishing, flooring, boat-building, barrels (interchangeable with white oak)
	red oak		barrels that hold dry goods only, flooring, interior finishing, furniture
	swamp white oak		flooring, interior finishing, cabinet work, furniture, boat-building, barrels
	white oak		furniture, flooring, interior finishing, boat-building, wine casks & barrels and other liquid containers (most important oak species)
Poplar	balsam poplar	soft and weak	plywood shavings, pulpwood
	eastern cottonwood		lumber, veneer (supply is limited)
	large tooth aspen		veneer, plywood, pulp, boxes & crates, matches
	trembling aspen		pulpwood, veneer, waferboard, chopsticks, boxes, crates, shavings, matches
Walnut	butternut	relatively soft wood	interior finishing, furniture, cabinet work
	black walnut		veneer for furniture, cabinets, interior finishings, boats (scarce)
Other Hardwood	basswood	relatively soft	veneer, plywood, furniture parts, hand-carving, modeling, turnery

Tree Species	Type	Information	Use
	beech		flooring, furniture, containers, handles, railway ties when treated with preservatives
	bitternut hickory		smoke flavouring of ham & bacon, sporting goods, tool handles
	black cherry	hard and strong	furniture making (scarce)
	black willow		pulpwood, furniture, doors, cabinets
	Ironwood	hardest & strongest	tool handles, applications requiring tough wood (scarce)
	white elm		caskets, paneling, furniture, boat building, unpolished used for fruit& vegetable containers
<u>Coniferous (SOFTWOOD)</u>			
<i>Pines</i>	eastern white pine		patterns, window sashes, frames, doors, mouldings, trim, siding, paneling, cabinet work (most valuable softwood in eastern Canada)
	jack pine		construction, pulp, poles, pilings, mine timbers, railway ties
	red pine	heavier and harder than eastern white pine	poles, piling, railway ties, planing mill products, pulp
<i>Spruces</i>	black spruce	soft and relatively strong	pulpwood, facial tissue, other paper products
	white spruce		pulpwood, lumber
<i>Other Softwood</i>	balsam fir		pulpwood, Xmas trees, (marketed as spruce)
	eastern hemlock	hard but not strong	coarse lumber, rough dimension stock, general construction, boxes, crates, railway ties, pulp
	eastern white cedar	light, soft and weak	posts, poles, shingles, boats, canoes
	tamarack	hard and oily	railway ties, poles, posts, piling, boxes, crates, boat-building, pulpwood

3. Exposure Standards and Limits

In Ontario sawmills and veneer plants, the two most prevalent exposures are wood dust and noise. Exposure to biological agents is also of concern but to a lesser extent.

3.1 Wood Dust

The most prevalent occupational exposure hazard in the forestry industry, sawmill and veneer plants is exposure to airborne wood dust. The allowable wood dust occupational exposure limits have been undergoing changes. In this section, the chronology of the occupational exposure standard is summarized. One of the oldest exposure standard setting organizations is the American Conference of Governmental Industrial Hygienists (ACGIH). The chronology of ACGIH TLVs for wood dust is given in Table 3. Total airborne dust and inhalable dusts are the two fractions used to assess wood dust exposure. This table notes if the inhalable airborne criteria/fraction should be measured. If it is not classified as inhalable, then total dust is the assumed criteria. In Table 4, the current available Canadian Provincial standards are shown. All standards listed in Table 4 are in terms of total dust. Since ACGIH's current wood dust standard is in terms of inhalable dust and the Ontario's provincial standards are in terms of total dust, a conversion of standards has been given in Table 5. This conversion is based on data from side by side sampling studies reported in the literature.

Table 3: ACGIH’s TLV Chronology of Wood Dust

Year(s)	TLV-TWA mg/m ³	TLV- STEL mg/m ³	Type of Wood Dust	Class
1972				
	5		Nonallergenic	
1981-present				
	1		Certain hardwoods (beech, oak)	
	5		Softwoods	
		10	Softwoods	
1998 (<i>proposed</i>)				
	0.5 (<i>inhalable</i>)		SEN – Western red cedar	
	5 (<i>inhalable</i>)		Hardwoods and softwoods (nonallergenic)	A1
			Certain hardwoods (beech, birch, mahogany, oak and walnut)	A1
			Softwoods (nonallergenic)	A4
			Hardwoods and softwoods (mixture)	A1
1999 (<i>proposed</i>)				
	0.5 (<i>inhalable</i>)		SEN – Western red cedar	A4
	5 (<i>inhalable</i>)		Hardwoods and softwoods (nonallergenic)	
			SEN – beech, oak	A1
			SEN – birch, mahogany, teak and walnut	A2
			Softwoods and other hardwoods (allergenic)	A4
2001 (<i>proposed</i>)				
	0.5 (<i>inhalable</i>)		SEN – Western red cedar	A4
	1 (<i>inhalable</i>)		SEN – other respiratory allergenic wood dust	A4
			Confirmed or suspected wood dust carcinogenicity	
			– beech, oak	A1
			– birch, mahogany, teak and walnut	A2
	2 (<i>inhalable</i>)		Nonallergenic and noncarcinogenic wood dust	A4
2003 (<i>proposed</i>)				
	0.5 (<i>inhalable</i>)		SEN – Western red cedar	A4
	1 (<i>inhalable</i>)		Nonallergenic species	
			All other wood dust species	A4
			Confirmed or suspected wood dust carcinogenicity	
			– beech, oak	A1
			– birch, mahogany, teak and walnut	A2
2005				
	0.5 (<i>inhalable</i>)		SEN – Western red cedar	A4
	1 (<i>inhalable</i>)		All other wood dust species	A4
			Confirmed or suspected wood dust carcinogenicity	
			– beech, oak	A1
			– birch, mahogany, teak and walnut	A2

Table 4: Available Provincial Wood Dust Standards (measured as total dust)

Province	Substance (Wood Dust)	TWA mg/m ³	STEL mg/m ³
BC	Allergenic species	1	
	Nonallergenic hardwood	1	
	Nonallergenic softwood	2.5	
QB	Western Red Cedar	2.5	
	All other types	5	
ON	Certain hardwoods (i.e. beech and oak)	1	
	Softwood	5	10
AB	Western Red Cedar	0.5	
	All other types	5	
SK	Certain hardwoods (i.e. beech and oak)	1	3
	Softwood	5	10
YK	Allergenic	2.5	5
	Nonallergenic	5	10

Table 5: Conversions based on ratio 2.5 of inhalable/total dust

Total Dust* (mg/m ³)	Inhalable* (mg/m ³)
5	12.5
2.5	6.25
1	2.5
2	5
0.4	1 ⁺
0.2	0.5 ⁺

(Ratio of 2.5 used for interpreting studies in TLV documentation of wood dust. It was noted that variability may be higher when total dust less than 0.5 mg/m³ and lower when mass is primarily due to small particles < 20 µm.)

⁺ 2005 adopted TLV values

3.2 Noise

Occupational exposure to noise is the next most prevalent exposure in this industry. Prolonged exposure to noise, over a period of time can cause hearing loss. Occupational exposure limits have been proposed in Ontario and elsewhere to prevent hearing loss among exposed workers. Current exposure limits for the Ontario regulation is essentially 90 dB(A) for 8 hours of exposure with 5 dB(A) exchange rate, also referred to as a doubling rate. The current Ontario noise regulation is shown in Table 6. The Ontario limit is proposed to be changed to be similar to ACGIH's current TLV of 85 dB(A) for 8 hours exposure with a 3 dB(A) exchange/doubling rate and a 140 dBC as a ceiling limit. This new regulation is scheduled to come into effect on July 1, 2007.[Ontario Ministry of Labour, 2006]

Table 6: Current Ontario Noise Regulation

Sound Level Decibels (dB)	Duration (Hours/24 Hour Day)
90	8
92	6
95	4
97	3
100	2
102	1.5
105	1
110	0.5
115	0.25 or less
Over 115	No exposure

3.3 Biological Agents

Biological agents such as bacteria and fungi are also of some concern. There is no specific standard in Ontario, but assessment is made by comparing biological agents in terms of colony forming units (CFU) found in outdoor to the indoor to assess workplace situations.

4. BRIEF REVIEW OF RELEVANT RESEARCH:

A brief overview pertaining to current and relevant research related to sawmill, plywood and veneer plants follows. For the sake of completeness the discussion includes topics that were not investigated in the feasibility study. Sawmill, plywood, and veneer plant workers are occupationally exposed to a variety of chemical, biological and physical agents. Potential exposures to major toxic and hazardous agents include wood dust, mould, terpenes, formaldehyde, isocyanates, noise and vibrations. A summary of the information follows.

4.1 Wood Dust – Particulates and Moulds

Saary and colleagues [Saary et al., 2001] assessed prevalence and nature of skin complaints in the refining and drying department of an Ontario particleboard manufacturing facility by subjecting volunteers to a standardized questionnaire concerning symptoms, past and family history, workplace exposures, and use of protective equipment, as well as a cutaneous examination (including patch testing) by a physician. In the questionnaire, workers complained of rash, nasal and eye irritation, cough and odours. Cutaneous examination identified various skin problems. Irritant dermatitis was identified more often than atopic dermatitis. Quaternium-15 was the only allergen to which more than 1 individual reacted. Aside from the odours, exposure to wood dust accounted for the other reported symptoms. The most significant confounder was exposure to wood dust outside of work. The authors concluded that irritant effects of exposure were more prevalent than allergenic effects.

A case-control study was conducted [Hildesheim et al., 2001] among 375 newly diagnosed cases of nasopharyngeal carcinoma (NPC) in Taipei, Taiwan, and 325 community controls matched to cases to evaluate the link between occupational exposures to wood dust, formaldehyde, and solvents and the development of disease. Most cases (>90%) were diagnosed with WHO Types 2 or 3, whereas the remaining cases were diagnosed with WHO Type 1. A complete occupational history was obtained by interview and assessed by an industrial hygienist for intensity and probability of exposure to wood dust, formaldehyde, and solvents. Information on socio-demographic characteristics, and other potential confounding factors was obtained. Blood was tested for various indicators known to be associated with NPC. Individuals exposed to wood dust had an adjusted RR of 1.7 (95% CI = 1.0-3.0). Those exposed to wood dust for >10 years had an adjusted RR of 2.4 (95% CI = 1.1-5.0; p(trend) = 0.02). Risk was strongest for those first exposed before the age of 25 years. Individuals exposed to formaldehyde were at an increased risk of NPC (RR = 1.4; 95% CI = 0.93-2.2). Those exposed to formaldehyde for >10 years had an adjusted RR of 1.6 (95% CI = 0.91-2.9). The association between formaldehyde and NPC was stronger in analyses restricted to EBV seropositive individuals (RR = 2.7; 95% CI = 1.2-5.9). However, no dose response was observed with increasing duration or cumulative use. No association was observed between solvent exposure and NPC (RR = 1.2; 95% CI = 0.86-1.7). They concluded occupational exposure to wood dust was likely to be involved in the development of NPC. Formaldehyde exposure was less clearly linked to NPC, whereas exposure to solvents is unlikely to be involved in NPC.

Dutkiewicz and colleagues [Dutkiewicz et al., 2001b] studied exposure to airborne micro-organisms in four Polish sawmills. Microbiological air sampling was performed at pine,

fir, oak and birch mills. Total concentration of micro-organisms in the air of sawmills processing coniferous wood was on average $20.2 \pm 5.6 \times 10^3$ cfu/m³ (mean \pm S.E.) and significantly ($p < 0.05$) higher compared to those processing deciduous wood where the mean concentrations of airborne micro-organisms was $9.8 \pm 3.0 \times 10^3$ cfu/m³. 34 species or genera of bacteria and 21 species or genera of fungi were identified in the air, of which respectively 13 and 9 species or genera were reported as having allergenic and/or immunotoxic properties. The authors concluded that workers of Polish sawmills might be exposed to airborne micro-organisms posing respiratory hazard, of which the greatest risk represented by allergenic fungi developing on bark of logs or stored wood products was endotoxin-producing gram-negative bacteria of the genus *Rahnella*. In a parallel study of one fibreboard and two chipboard factories in Poland for bioaerosol exposures by the same investigator [Dutkiewicz et al., 2001a], they concluded the workers of fiberboard and chipboard factories may be exposed during the initial stages of the production cycle (shredding of waste wood, storing of chips) to high levels of airborne micro-organisms and endotoxin posing respiratory hazard.

Dutkiewicz and colleagues [Dutkiewicz et al., 2001c] studied the reactivity of sawmill workers to biological allergens associated with wood dust. Skin allergy examinations and precipitin tests were performed in 43 workers employed in a sawmill processing pine, in 90 workers employed in two sawmills processing oak, and in 32 healthy urban dwellers (controls - not exposed to organic dusts). Workers processing pine showed a very high frequency of positive skin reactions to the extract of wood dust, significantly greater compared to workers processing oak and referents ($p < 0.001$). The frequency of reactions to gram-negative bacterium *Rahnella* sp. was significantly greater in the pine processing workers than in the oak processing workers and referents ($p < 0.001$). Oak processing workers reacted significantly more frequently to *Penicillium citrinum*, compared to the pine processing workers and referents ($p < 0.01$). The antibody response of sawmill workers to work-related antigens was much weaker compared to skin reactions. A significant relationship was found between the occurrence of symptoms and frequency of allergic reactions, but only with a limited number of antigens. The authors suggested that early allergic reactions to coniferous wood and to micro-organisms associated with wood dust were common among sawmill workers, posing a potential risk of work-related disease.

In another study, [Duchaine et al., 2000], particulates and bioaerosols in Eastern Canadian sawmills were quantified and identified. Within each of the 17 Quebec-based sawmills, different work sites (debarking, sawing, sorting, or planning) were studied separately. Area sampling was performed. Microbial contaminants were assessed with all-glass impingers and six-stage Andersen microbial samplers; appropriate selective media and culture conditions for bacteria, thermophilic actinomycetes, moulds, and yeasts were used. Inhalable dust, endotoxins, temperature, and humidity were measured. *Penicillium* species were the most predominant moulds. The debarking work sites were highly contaminated by moulds, bacteria, and endotoxins ($p=0.0001$). Planning sites were highly dust contaminated (median: 3.0 mg/m^3) ($p < 0.05$). They concluded that sawmills of eastern Canada contained airborne biological contaminants that varied between working sites. Microflora were different from that described in European sawmills.

In a study of 4 BC sawmills [Ronald et al., 2003], wood dust samples and potential exposure determinants were studied. Researchers found that the highest levels of Beta(1->3)-glucans were measured at the Interior mills, particularly in the log processing and sawmill areas. Multivariate regression models indicated that land-based log storage, clean-up jobs, high wood dust concentration, lumber yard department and the interaction between land-based log storage method and log processing department were associated with increased beta(1->3)-glucan concentration.

Cormier and colleagues [Cormier et al., 2000] evaluated respiratory health impact of working in sawmills in Eastern Canada. The authors measured respirable dust, bacteria, endotoxins, and moulds collected from 17 sawmills in eastern Canada. A total of 1,205 sawmill workers answered a respiratory-health questionnaire, and participated in lung-function measurements, skin-prick tests, and blood sampling for specific immunoglobulins against moulds found in the sawmills. Workers had normal lung functions, and most respiratory symptoms could be explained by smoking histories. Workers in pine sawmills had a greater prevalence of positive skin-prick test to pine than did workers in sawmills where other woods were used. High levels of specific antibodies were seen in some workers. Quebec sawmill workers did not experience significant respiratory illnesses. The authors concluded that some workers may be at a higher risk of developing asthma and hypersensitivity pneumonitis than non-workers.

A Canadian study [Demers et al., 2000] assessed exposure to potential respiratory hazards in a large lumber mill processing spruce, pine, and fir in Western Canada. Personal samples for inhalable particulate were collected to measure exposure to dust and resin acids (abietic acid and pimaric acid). To estimate wood dust exposure, the resin acid content within dust was used in combination with observations of job tasks and proximity to dust sources. Passive dosimeters were used to measure exposure to alpha-pinene, beta-pinene, delta 3-carene, and other unidentified wood volatiles suspected to be monoterpenes. The geometric mean (GM) of the 220 inhalable particulate samples was 1.0 mg/m³ whereas the mean abietic acid, pimaric acid, and estimated wood dust levels were 7.2 µg/m³, 0.6 µg/m³, and 0.5 mg/m³, respectively. The GMs of the 222 monoterpene samples were 0.1 mg/m³ for alpha-pinene, 0.3 mg/m³ for beta-pinene, 0.1 mg/m³ for delta 3-carene, and 0.5 mg/m³ for the unidentified wood volatiles. Monoterpene exposures were much lower than those observed in studies conducted in Sweden and Finland.

Alwis and colleagues [Alwis et al., 1999b] wrote a paper in which workers at four different woodworking processes (2 logging sites, 4 sawmills, 1 major wood chipping operation, and 5 joineries) in South Wales, Australia were studied for personal inhalable dust exposures (N = 182). The geometric mean exposure at logging sites was 0.6 mg/m³ (N = 7), sawmills 1.6 mg/m³ (N = 93), woodchipping 1.9 mg/m³ (N = 9), and joineries 3.7 mg/m³ (N = 66). Overall, 62% of the exposures exceeded current standards. Among joineries, 95% of the hardwood exposures and 35% of the softwood exposures were above the relevant standards.

The same author [Alwis et al., 1999a] studied personal exposure to fungi, bacteria, endotoxin, and (1->3)-beta-D-glucan at logging sites, sawmills, woodchipping sites, and joineries. Exposure levels to fungi at logging sites and sawmills were in the range of 10³-10⁴

cfu/m³, at the woodchipping mill, 10³-10⁵ cfu/m³, and at joineries, 10²-10⁴ cfu/m³. Although mean endotoxin levels were lower than the suggested threshold value of 20 ng/m³, some personal exposures at sawmills and a joinery exceeded the standard. Highly significant associations were found between mean personal inhalable endotoxin exposures and Gram-negative bacteria levels ($p < 0.0001$), and mean personal inhalable (1-->3)-beta-D-glucan exposures and fungi levels ($p = 0.0003$). The prevalence of cough, phlegm, chronic bronchitis, nasal symptoms, frequent headaches, and eye and throat irritations was significantly higher among woodworkers than controls. Dose-response relationships were found between personal exposures and work-related symptoms among joinery workers and sawmill and chip mill workers.

A study [Hessel et al., 1995] was undertaken to investigate the respiratory health of a group of Alberta sawmill workers processing pine and spruce ($n = 94$). Data collection included a respiratory symptom questionnaire, spirometry, and allergy skin testing. The sawmill workers were compared with a group of oil field workers from the same geographic area ($n = 165$). The results showed that the sawmill workers had significantly lower average values for FEV1 and FEV1/FVC (%), adjusted for age, height, and smoking. The largest differences were for current smokers. Sawmill workers were 2.5 times as likely as oil field workers to report current asthma (95% CI, 0.76 to 8.32). Workers employed more than 3 years showed significantly more asthma (OR = 3.67; 95% CI, 1.00 to 13.5) and bronchitis (OR = 2.14; 95% CI, 1.02 to 4.52). Sawmill workers were only 43% as likely to report a history of hay fever (95% CI, 0.20 to 0.94). These health effects were noted despite an average concentration of respirable dust of 1.35 mg/m³ (range, 0.1 to 2.2 mg/m³).

Siracusa and colleagues [Siracusa et al., 1995] evaluated the prevalence of asthma and its predictors in studies of several Canadian male working groups: 619 cedar sawmill, 724 grain elevator, 399 pulp mill, 798 aluminum smelter, and 1,127 unexposed workers. The American Thoracic Society Adult Questionnaire (ATS-DLD-78) was used for the study. Allergy skin tests were also performed. The participation rates were > 80%. The overall prevalence of physician-diagnosed asthma was 4.6%, and current asthma 3%. The prevalence of asthma after employment in the current industry, as a surrogate for work-related asthma, was 3.9 times higher in cedar sawmill workers, 2.2 times higher in pulp mill and aluminum smelter workers, and 1.7 times higher in grain elevator workers compared with unexposed workers. Atopy and a positive parental history of asthma, but not smoking, were important risk factors for asthma before the onset of first employment. Also, for asthma after employment in the current industry, atopy and a positive parental history of asthma were important risk factors. Smoking was associated with a significant reduction in the risk for asthma after employment in the current industry. Within specific work groups, the prevalence of atopy was significantly higher among pulp mill workers with asthma after employment in current industry than those without asthma. Conversely, cedar sawmill workers who had asthma after employment in the industry were non atopic and nonsmokers.

Malo and colleagues [Malo et al., 1994] assessed the prevalence of occupational asthma among current ($n = 29/31$, 94%) and former ($n = 13/49$, 27%) employees of a sawmill processing eastern white cedar into shingles. All participants answered a respiratory questionnaire, and all except one underwent spirometry and methacholine inhalation tests. All

those with bronchial hyper responsiveness (PC20 methacholine \leq 19 mg/ml) were invited to undergo specific inhalation challenges. Twenty-eight workers (65%) reported a history of asthma, and 25 (58%) had symptoms suggestive of occupational asthma. Only two subjects had significant airway obstruction (FEV1 $<$ 80% pred) (mean value = 98% pred). Eighteen subjects (42%) had a PC20 \leq 16 mg/ml. Specific inhalation tests with plicatic acid and/or western red cedar were done on 12 subjects who had a PC20 \leq 16 mg/ml when they were assessed. Three subjects were considered to have positive tests (one had an isolated immediate reaction, one had a late reaction, and one had significant changes in PC20 each time he was exposed but no changes in FEV1). Environmental monitoring showed concentrations of total dusts above 2 mg/m³ in half of the samples. The prevalence of occupational asthma in this workplace was three of 42 participants (7%).

Teschke and colleagues [Teschke et al., 1994] measured personal respirable (N = 230) and total (N = 237) dust in two coastal British Columbia sawmills using a sampling strategy that randomly selected workers from all jobs in the mills over two seasons. Information about job title, department, season, weather conditions, location of the job relative to wood-cutting machines, and control measures was collected. 16 respirable wood dust samples had levels \leq 0.20 mg/m³. Total wood dust concentrations were also low (36% less than the detection limit), with a mean of 0.51 mg/m³, and ranging from $<$ 0.08 to 52mg/m³. Measurements of exposure taken close to chippers, planers, and multiple saws had the highest total wood dust levels. Sawmill department and booth enclosures also were associated with wood dust concentrations, while local exhaust ventilation and weather conditions were not. They concluded that wood dust levels in this study were generally lower than in other studies of this industry.

In 1984-85, a study of wood dust exposure in the Ontario industry was jointly conducted by Michael Holliday and Associates and the Ontario Research Foundation. The report provides information based on contacts with nearly 100 companies, labour union, trade associations, replies to mail out questionnaires to 875 wood processing companies (over 50% response achieved) and industrial hygiene surveys of 23 plants. This study provides an overview of the wood dust exposure status of industry at that time [Holliday et al., 1985]. This study had included primary wood industry groups (i.e. saw mills and veneer plants), secondary industry groups (i.e. millwork, prefab building, wood products group), and the tertiary industry group (i.e. kitchen cabinet making, household and office furniture making plants). Both personal and area samples were taken. A total of 198 samples were obtained (148 personal and 50 area samples). Personal exposures to wood dust ranged from 0.1 to 6.1 mg/m³ for primary industry groups, 0.3 to 15 mg/m³ for secondary industry groups and 0.3 to 15.6 mg/m³ for tertiary industry groups. Overall primary groups (sawmill and veneer plants) had the lowest exposure and tertiary industries (cabinet and furniture making) had the highest exposure. Unfortunately, the results of this very useful study were not published in any peer reviewed journal and thus are not widely known.

Sass-Kortsak and colleagues [Sass-Kortsak et al., 1986] studied wood exposure in the Ontario cabinet-making industry. Total and respirable dust exposures (personal and area) were determined in 4 plants. Formaldehyde (personal and area) exposures also were obtained with various devices. Softwood exposures were considerably lower than hardwood exposures.

The highest dust exposures were recorded for those workers sanding, the mean total dust being 2.91 mg/m³ (S.E. 0.70) and respirable dust 0.63 mg/m³ (S.E. 0.20). Total dust samples were poorly correlated with respirable dust concentrations indicates that both measurements should be made. Area dust concentrations were found to be significantly lower than personal exposures, emphasizing the importance of personal sampling data. Formaldehyde vapour exposures were very low, with a mean of 0.06 ppm (S.E. 0.01).

Oppliger and colleagues recently published a study of worker exposure to fungi and bioaerosols in 12 Swiss sawmills [Oppliger et al., 2005]. Samples were collected at different work sites (debarking, sawing, sorting, planing and sawing cockpit). Results showed that fungi were present in very high concentrations (up to 35 000 CFU m⁻³) in all sawmills. Sorting work areas showed the higher levels for total bacteria, Gram-negative, fungi, endotoxin and dust than at the sawing station. Penicillium sp. were the predominant fungi, while Bacillus sp. and the Pseudomonadacea family were the predominant Gram-positive and Gram-negative bacteria.

4.2 Formaldehyde

Vaughan and colleagues [Vaughan et al., 2000] investigated whether occupational exposures to formaldehyde and wood dust increased the risk of nasopharyngeal cancer. A multi-centered, population based case-control study was carried out in the United States. Cases (n=196) with a newly diagnosed NPC between 1987 and 1993, and controls (n=244) selected over the same period from the general population participated in structured telephone interviews. Histological type of cancer was abstracted from clinical records. Potential exposure to formaldehyde and wood dust was assessed on a job-by-job basis by experienced industrial hygienists blinded as to case or control status. For formaldehyde, after adjustments, a trend of increasing risk of squamous and unspecified epithelial carcinomas was found for increasing duration ($p=0.014$) and cumulative exposure ($p=0.033$) but not for maximum exposure concentration. The odds ratio (OR) for people cumulatively exposed to >1.10 ppm-years was 3.0 (95% confidence interval (95% CI) 1.3 to 6.6) compared with those considered unexposed. The associations were most evident among cigarette smokers. By contrast, there was no association between potential exposure to formaldehyde and undifferentiated and non-keratinising carcinomas. There was little evidence that exposure to wood dust increased risk. These results support the hypothesis that occupational exposure to formaldehyde, but not wood dust, increases risk of NPC.

In a different study [Makinen et al., 1999] respiratory and dermal exposure to phenol-formaldehyde resin-glue components used in plywood manufacturing were assessed. Formaldehyde and phenol were monitored in the workplace air. Formaldehyde was measured both in the breathing zones of the workers and at stationary sampling sites. Sampling and analytical methods were developed to measure the dermal exposure to phenol. In addition, a liquid chromatography method was developed for the analysis of phenol from dermal exposure samples. Formaldehyde was noted to be the major compound causing respiratory exposure. The dermal sampling revealed that the workers were exposed to phenol, but the risk for toxic effects was slight due to the low concentrations of urinary phenol.

In a recent New Zealand study of the plywood industry [Fransman et al., 2003] occupational exposure measurements of inhalable particulate, bacterial endotoxins, abietic acid, terpenes and formaldehyde were related to a respiratory health questionnaire. It was only in respect to formaldehyde exposure that there was a positive association between exposure and the report of asthma symptoms.

Two other separate studies of case reports implicated phenol-formaldehyde resins in the development of allergic contact dermatitis [Aalto-Korte et al., 2003; Rademaker, 2002]. Workers were exposed to uncured resins or components.

4.3 Terpenes

In the most recent study [Rosenberg et al., 2002] on work-related symptoms among Finnish sawmill workers exposed to monoterpenes and wood dust, researchers studied 22 sawhouse workers who process pine and spruce in 1997-99. Exposure to monoterpenes was assessed by determining monoterpenes in air and verbenols in urine. Wood dust was determined gravimetrically. A questionnaire was used to evaluate work-related subjective symptoms. Exposures to monoterpenes (geometric mean, GM) among sawhouse workers were 61-138 mg/m³ and 2.0-13 mg/m³ during processing of pine and spruce, respectively. Urinary verbenol correlated well with worker exposure to the alpha-pinene fraction of monoterpenes. The inhalable dust concentration in the breathing zone was 0.5- 2.2 mg/m³ during pine processing and 0.4-1.9 mg/m³ during spruce processing. The prevalence of symptoms, in the eyes or respiratory tract, was high during both seasons and in connection with either tree species. The concentrations of inhalable dust (GM) were less than one-half the Finnish OEL (5 mg/m³). No significant differences in dust exposure were observed among tree species processed. Work-related symptoms appeared to correlate with monoterpene exposure during processing of pine and with wood dust exposure during processing of spruce.

Eriksson and colleagues [Eriksson et al., 1996] researched terpene exposure and respiratory effects among sawmill workers. The relationships between personal exposure to sawing fumes, assessed by air sampling, and terpene metabolites in urine were studied. The association between exposure to terpenes and acute effects on lung function was studied for 48 workers. The reactivity to methacholine within the study population was investigated. Variation in acute subjective respiratory symptoms during a work shift was evaluated by interviewing the employees before and after work, following a standardized questionnaire. Personal exposure to terpenes in the sawmills was 11-158 mg/m³. Workers with > or = 5 years of sawmill employment showed a higher reactivity to methacholine than those with < 5 years. Eye irritation increased during a workday. They concluded that exposure to monoterpenes during a work shift sometimes exceeded the Swedish limit value. Exposure in sawmills can cause an acute decrease in diffusing capacity. Workers with < or = 5 years employment showed increased bronchial reactivity.

In a later study [Eriksson and Wiklund, 2004], patch testing was used to ascertain occupational exposures to allergenic monoterpenes. Sampling and testing of the patch devices was carried out in mills where pine and spruce species were handled. Highest average dermal exposures were observed during sawing rather than handling. Patches placed under protective clothing contained monoterpenes indicating contamination of the skin.

Another study compared air testing versus biological monitoring for monoterpenes [Liljelind et al., 2003]. Researchers found that variance in air samples were similar to variance found in biological samples (metabolites in urine). It was suggested though that air samples provide better quality exposure information than biologic samples as they are less subject to variance. It had previously been postulated that biological monitoring would be the higher standard of occupational exposure assessment, but the study authors concluded the opposite.

4.4 Chlorophenates

Walls and colleagues [Walls et al., 1998] carried out a preliminary study of the health effects of occupational pentachlorophenol exposure in timber sawmill employees. A questionnaire-based, non-random survey was undertaken amongst a group of current and ex-workers who had identified their health concerns as being related to PCP exposure. Low, medium and high exposure groups were identified. A significant dose-response was found between past exposure to Pentachlorophenol and reported symptoms of fever/sweating (47% in the high exposure group), weight loss (33% in the high exposure group), persisting fatigue (74% in the high exposure group), nausea (40% in the medium and high exposure groups) and responses to a screening test for neuropsychological dysfunction (Questionnaire 16) (81% in the high exposure group). No associations were observed with other chronic diseases, apart from emphysema and chronic bronchitis. The findings were preliminary and the authors didn't draw any conclusions.

Heacock and colleagues [Heacock et al., 1998] studied fertility among a cohort of male sawmill workers exposed to chlorophenate fungicides. They expected to determine whether exposure to chlorophenate fungicides and their dioxin contaminants was associated with male infertility among sawmill workers. The study was conducted using fertility data compiled from 26,487 sawmill workers in 14 British Columbian sawmills. They assessed fertility trends by internal comparison using Mantel-Haenszel rate ratios and by calculating standardized fertility ratios using an external and an internal reference population. Initial external and internal analyses showed that sawmill workers from mills using chlorophenates had lower fertility than workers employed in mills not using chlorophenates. After controlling for time since first hire, however, they found no inverse relation between cumulative exposure to chlorophenate fungicides and fertility. Based on the results of the study, there was little evidence for a reduction in fertility among chlorophenate-exposed sawmill workers in British Columbia.

The same research group published a report in 1997 [Hertzman et al., 1997] on mortality and cancer incidence among sawmill workers exposed to chlorophenate wood preservatives. This study examined the association between exposure to chlorophenates and the risk of soft tissue sarcoma; non-Hodgkin's lymphoma; Hodgkin's disease; and cancers of the lung, nose, and nasopharynx. A retrospective cohort study was conducted of 26487 workers employed for at least 1 year between 1950 and 1985 in 11 chlorophenate-using and 3 non-using sawmills in British Columbia, Canada. Exposures by job were ascertained; none of the cancers of interest had elevated mortality related to chlorophenate exposure. Non-Hodgkin's lymphoma incidence (n = 65) increased with increasing chlorophenate exposure hours, yielding the following standardized incidence ratios: less than 120 hours 0.68; 120 to 1999 hours, 0.59; 2000 to 3999 hours, 1.04; 4000 to 9999 hours, 1.02; and 10000 or

more hours, 1.30. These results indicated borderline positive associations seen in other reported studies of chlorophenolate-exposed workforces.

Jappinen and colleagues [Jappinen et al., 1989] assessed the cancer incidence of 1,223 sawmill workers with continuous employment of at least one year between 1 January 1945 and 31 December 1961 was followed until 31 December 1980. Separate analyses were made for the 801 workers hired after 1 January 1945, and smoking habits were surveyed. Among the men, 90 cases of primary cancer were detected versus 83.5 expected and among the women 55 cancer cases versus 44.5 expected. Skin cancer was in excess among the men, especially among those employed after 1 January 1945. Lip, mouth, and pharynx cancer and lymphomas were also slightly in excess among the men, as was leukemia among both sexes. They concluded that workplace exposure, especially to chlorophenols, may be associated with the excess skin cancer and the slight excess of lymphomas.

Demers et al. [Demers et al., 2006] studied the carcinogenicity of pentachlorophenol and tetrachlorophenol in BC sawmill workers in a cohort consisting of 27,464 men employed by 14 sawmills for 1 year or more between 1950 and 1995. Of the 1,495 fatal cancer and 2,571 incident cancers, there were no large or statistically significant excesses of any of the specific cancers compared to the general population. There was a strong dose-response relationship for exposure to pentachlorophenol and non-Hodgkin's lymphoma, multiple myeloma, and kidney cancer.

4.5 Noise and Other Exposures

Vinzents and Laursen [Vinzents and Laursen, 1993] carried out a cross-sectional survey in the Danish wood and furniture industry at 200 factories. Representative estimates of employees' full-shift exposures to wood dust, vapours from organic solvents, formaldehyde and noise dose were calculated using a model for two-stage cluster designs. Exposures to air pollutants were generally below the occupational exposure limits (OELs), while noise doses were at the same level as OEL. The overall exposure to wood dust was 0.90 mg/m³, exposure to vapours from organic solvents was 0.13 C/OEL and noise dose, Leq (8 h), was 90.5 dB(A).

Noise levels were studied at 9 Alberta sawmills, with 213 personal noise exposure samples taken in summer and winter [Koehncke et al., 2003]. Noise reduction ratings from personal protective devices were factored into personal noise dose calculations. Only 10% of measurements were below the provincial 8-hr exposure limit of 85 dB(A). 27 percent of measurements were 95 dB(A) or higher. Enclosures were effective at reducing noise exposure. The authors concluded that in the planning department, workers are at risk of being overexposed to noise even when equipped with hearing protection devices.

A recent study evaluated the effectiveness of alternative technologies for micro-organism control in sawmills [Gutierrez et al., 2005]. Exposure to 2,4,6-tribromophenol (TBP) was evaluated in a variety of processes using biological monitoring of worker exposures. Researchers found that hydraulic immersion resulted in low occupational exposures, but the chemical recovery, work practices and waterproofing were necessary factors to consider in reducing total exposures.

Bergstrom and Nystrom conducted a 20-year follow-up study assessing hearing loss due to long-term occupational noise exposure (NIHL) [Bergstrom and Nystrom, 1986]. Repeated hearing tests over a 20-year period were performed on 319 employees of a timber processing firm, working in sawmills and paper pulp production, exposed to mean noise levels of around 95-100dB(A) and in a chemicals division with mean noise exposure levels of 80-90 dB(A). During the observation period, mean hearing levels deteriorated slowly, especially at 4 kHz, but no dramatic changes from one year to another were seen.

Airborne concentrations of methylene diphenyl diisocyanate (MDI) were assessed in North American oriented strand board (OSB) mills [Karoly et al., 2004]. Of the 578 samples covering 11 different job titles, 97% of the personal samples and 92% of the area samples were below an 8-hr time weighted average threshold level of 0.051 mg/m³. Wipe tests on surfaces for unreacted diisocyanates came back positive for 13% of the samples. Maintenance of engineering controls, proper work practices and use of personal protective equipment were deemed essential for controlling exposure.

4.6 Summary

The recent studies have certainly provided light on the types of hazards to be expected in Ontario sawmills and other wood-processing facilities. The studies conducted in Eastern Quebec [Cormier et al., 2000; Duchaine et al., 2001] and BC [Demers et al., 2000; Teschke et al., 1994] shed some light on dust and microbiological hazards in Canada. This subject was raised when their findings on some fungal strains differed from those found in Europe [Demers et al., 2000]. This may account for the conflicts in findings with respect to allergenic responses [Dutkiewicz et al., 2001c; Saary et al., 2001]. Issues have also been raised with respect to the contribution of non-wood dust to total inhalable dust [Demers et al., 2000]. It should be reasonably expected that non-wood dusts at manufacturing sites, such as road dust, soil, and diesel exhaust, could contribute significantly to the total dust burden. True wood dust concentrations need to be determined. Other deficiencies have been noted in other papers as well - participation rate [Saary et al., 2001], and misclassification [Hildesheim et al., 2001]. Some studies were just too small to make conclusions about the industry in general [Eriksson et al., 1996]. The relationship between wood dust exposure and nasal cancer in this industry has not been firmly established. Epidemiologic studies have been limited to case-control studies [Saary et al., 2001] or retrospective cohort studies [Bergstrom and Nystrom, 1986; Heacock et al., 1998; Hertzman et al., 1997; Jappinen et al., 1989]. The pooled evidence suggests a relationship between exposure and some types of disease; however, the evidence is weak. Moreover, none of these studies have attempted to quantify, exposure retrospectively. A literature review revealed weaknesses in knowledge in several areas. With respect to noise, formaldehyde, chlorophenates, and terpenes, there is not enough quantitative information to make a determination of these exposures in Ontario. Chlorophenate fungicides are now banned from BC, however, there is no information as to their use in Ontario. Information on formaldehyde use in Ontario and terpene exposures are also unavailable. IARC [IARC, 1995b] has refused to classify wood-processing industries with respect to carcinogenicity due to the lack of published evidence.

5. RESEARCH OBJECTIVES:

The **PURPOSE OR MAIN OBJECTIVE** of this small scale feasibility study as stated earlier was to determine whether a full two year study involving extensive sampling of airborne chemical, biological and physical agents in sawmills (2002 WSIB rate group 033) and plywood/veneer mills (2002 WSIB rate group 036) is reasonable to provide data for health study and direction for future initiatives in this industry.

Early in the original grant application process, the researchers consulted with industry stakeholders in an effort to develop study objectives and research protocol. Available literature was consulted and researchers from other Canadian research institutions in Quebec and British Columbia were consulted. The researchers from McMaster consulted with managers and consultants at the Ontario Forestry Safe Workplace Association, which is mandated by the Workplace Safety and Insurance Board of Ontario to lead incident and occupational illness prevention initiatives for the Ontario forestry industry. Further, the researchers visited a major sawmill in Huntsville Ontario to gain a better understanding for sawmill work processes and related exposures.

5.1 Specific Goals

The specific goals of this feasibility study were to:

- Obtain the co-operation of the stakeholders, employers, workers and unions for a future “proposed full-study”.
- Meet with joint occupational health and safety committees (where they existed), health and safety professionals and other workplace parties, both at OFSWA and at the workplaces to determine the areas of concern in relation to occupational exposure and health effects.
- Visit a representative number of workplaces ranging from small to large firms to conduct preliminary “walk-through” hygiene surveys and to learn first-hand about the occupational health and hygiene challenges in the sawmill and plywood/veneer industries.
- Make preliminary measurements of occupational exposures to contaminants such as wood dust, noise, and mould to assess the analytical requirements for a major study.
- Ascertain what types of health outcomes can be measured in the workplace as part of a future study. Determine quantity and quality of data including available medical surveillance, historical air sampling, employment records, etc.

6. METHODS:

The research procedure was focused on information gathering through two primary means – questionnaires and observational surveys.

6.1 Questionnaire Survey

It was important to survey the industry for indicators of work practices, occupational exposures, health issues, training and concerns. A listing of firms was obtained from the Ontario Forestry Safe Workplace Association. The names of all 2002 active firms in rate groups 033 (Sawmills) and 036 (Plywood/Veneer mills) were obtained. Firms were broken down into firm size (full time equivalents) and OFSWA consultant regions. Firms' sizes (in workers) ranged from 1-5, 6-19, 20-49, 50-99, 110-150, and greater than 150. Questionnaires were created for health and safety managers, small business operators, health and safety representatives, and joint health and safety committee representatives. Copies are included as Appendix I to IV. The questionnaires gathered information on workplace characteristics, demographics, health and safety practices, and opinions respecting occupational health, hygiene and safety matters assessed perceptions about occupational health and safety. According to OFSWA data, more than 85% of all firms employed less than 20 workers. The number of firms with more than 20 workers was limited. To increase the robustness of data for larger firms, we therefore sent questionnaires to all firms registered as employing 20 or more workers. For firms in the 1-5 and 6-19 employee categories, 50% of the firms in the 6-19 category were selected (using a random number generator) from the various regions. Firms were assigned a code and these codes were marked on the questionnaires. The same procedure was used to select 20% of the firms with 1-5 workers. A list of the selected firms was sent to OFSWA and the mailing address labels were obtained. Following an initial mailing of the questionnaires, a second mailing was sent out.

6.2 Observational (Walk-thru) Survey

Following the questionnaire survey, on-site visits were arranged through the OFSWA. The purpose of the site visits were to: survey site conditions and to assess the various processes for occupational health hazards, consult with site-staff about occupational health issues and problems, validate responses to the questionnaires, conduct measurements for dust, noise, mould, and take note of other potential exposure for others contaminants.

Two study investigators conducted site visits to selected sawmills, plywood and veneer plants around Ontario, with the exception of North-Western Ontario. This region was not included due to a market downturn and, therefore, limited availability of participants. At least one company representative accompanied the investigators during each visit. Visits typically lasted between 2 and 4 hours and comprised of an initial meeting with a company representative, administration of a follow-up questionnaire and a subsequent walkthrough tour of the facility. Where possible, production process flow was followed from the log yard to final product staging/packaging. Due to time limitations, and production downtime, not all process locations could be evaluated.

Prior to the walk-thru tour at each plant, the contact person for the facility was asked to complete the same questionnaire they had previously received by mail. Re-administration of the questionnaire served to validate the responses given on the original version and helped to identify any changes that may have occurred since then. The site visit questionnaire was verbally administered by one of the investigators.

Walkthrough segments of each visit enabled several parameters to be measured in an attempt to provide a cursory characterization of the work environment. A total of 22 different site visits from 17 different companies were performed over a 3 year period (2003-2005).

Measuring devices used in the walk-thru surveys are shown in Figure 6. They are (a) real-time direct reading dust monitor, (b) sound level meter, (c) dosimeter, and (d) bioaerosol and mould sampler.

Figure 6: Dust, Noise and Biological Sampling Equipment

(a) sound level meter, (b) real-time direct reading dust monitor, (c) bioaerosol and mould sampler, and (d) dosimeter



6.2.1 Wood Dust

Airborne dust (wood dust) measurements were performed using a real-time direct reading dust monitor (DustTrak, Model 8520 Aerosol Monitor, TSI Inc., Shoreview MN, USA), Fitted with a 10 micron nozzle. Although wood dust is considered to be inhalable, the DustTrak provided a qualitative evaluation of the dust at various work stations within each plant and serves as a reliable estimator of dusty conditions. The 10 micron inlet nozzle roughly approaches the fraction of dust which would be measured by the total dust closed face assembly system. A recent paper demonstrated the validity of using such surrogate measures for airborne dust in sawmills when comparing historical exposure data to current data using inhalable dust techniques [Friesen et al., 2006].

6.2.2 Noise

Noise levels were monitored with a Type 1 Sound Level Meter (Model 2230, Bruel and Kjaer, Denmark) and a noise dosimeter (Spark 706 Noise Dosimeter, Larson Davis Inc., Provo, UT, USA). Noise exposure information with respect to the Ontario regulation is detailed in Table 6.

6.2.3 Biological Agents

Preliminary biological agent assessment of bioaerosol and mould was completed at several locations with a Reuter Centrifugal Air Sampler (RCS) (Biotest AG, Dreieich, Germany). Bioaerosol was collected by impaction onto a flexible strip containing 34 agar-filled wells housed in the perimeter of the instrument's impeller head. Following air sampling, the potentially bioaerosol-laden agar can be analyzed for fungal growth. The RCS, which has an effective air sampling flow rate of 40 litres per minute (lpm), was typically run for 1 or 2 minutes at 2 indoor and 1 outdoor location in the plant.

6.2.4 Other Potential Exposure

There are several other potential harmful exposures that can be present in the forest industry such as formaldehyde, phenol, terpenes, and chlorophenates. Vibration could also be a problem. None of these were assessed in this preliminary investigation.

7. RESULTS:

Results of the questionnaire surveys and the walk-thru surveys are given in the following sections.

7.1 Questionnaire Survey

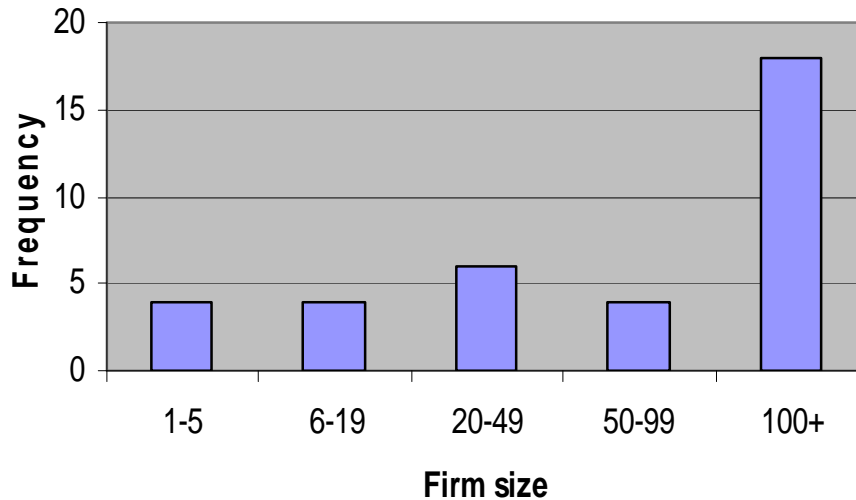
35 firms responded to the questionnaires by completing and returning them. Another 18 declined to complete the survey. One was returned to sender and another one reported no longer being in business. Half of the firms completing the survey declared that they employed 100 or more full time and/or part time workers (see Table 7 and Figure 7). The mean number of workers employed by respondents was 96.4. The median value was 85. The smallest number of workers employed was 2 as compared to 420 for the largest firm. Only 4 of the questionnaires out of 38 were returned from employers with 5 or less workers. Another 4 out of 42 were returned by firms employing 6-19 workers. Only 8 firms in total meeting the definition of small business according to the WSIB (firms employing less than 20 workers) responded to the survey. Many of the large firms (by comparison) – 27 out of 93 - registered in the province completed and returned their questionnaires.

Table 7: Questionnaire Respondents (based on firm size)

Firm Size	Number of Firms
1-5	4
6-19	4
20-49	6
50-99	4
100+	17

Statistics	
Mean	96.4
Standard Error	15.8
Median	85
Mode	150
Standard Deviation	93.5
Sample Variance	8737.8
Kurtosis	3.5
Skewness	1.6
Range	418
Minimum	2
Maximum	420
Sum	3375
Count	35
Confidence Level (95.0%)	32.1

Figure 7: Graph of Questionnaire Respondents (based on firm size)



7.1.1 Industry Characteristics

According to respondents, both softwood and hardwood species of woods are processed by sawmill and the plywood/veneer industry. From valid responses (32, 3 were unclassifiable) the average firms reported that they process approximately 55% softwoods and 45% hardwoods, although the reported wood use per employer varied widely. 12 firms reported that they use softwoods exclusively, while 8 firms reported that they use hardwoods almost exclusively (See Figure 8). Other firms reported a varying mix of both softwoods and hardwoods. The most frequently reported softwood used in Ontario was spruce. Jack pine, white pine, and red pine were also reported to be in wide use. Maple, poplar and birch are the most popular species of hardwoods used in Ontario. 18 of the 36 firms reported themselves and sawmill or planer mills. Others reported as being veneer plants, plywood plants, particleboard plants, waferboard plants or oriented strand board plants. Most of the firms reporting to use 100% hardwood were also associated with plywood or oriented strandboard manufacturing.

16 of the 35 firms reported that at least 25-50% of workers regularly worked shifts lasting more than 8 hours per day (including overtime). Of those 16 firms, 12 reported that more than 50% of the workforce worked more than 8 hours per day on average. Many of the plants reported that the workforce worked on day or afternoon/evening shifts. 15 of the firms reported that they have rotating shifts. 2 out of the 35 firms employed more than 75% of the workforce as short-term workers (summer, co-op, seasonal). The vast majority reported having short-term workers as less than 25% of the total workforce.

In terms of demographics of the workforce, on average 19% of the workers employed in the industry are under 25 years of age. 64% of the workforce was 25-49 years of age, and 17% of the workforce was 50 years and older (see Figure 9). 3 firms reported that young workers (25 years or less) made up more than 50% of their workforce with 2 of those firms employing young workers almost exclusively. With respect to years of service, 17% of the workforce on average had worked for less than 2 years at the current employer. 21% had 2-5 years of service, and 62% of workers on average had worked at the same employer for more than 5 years (see Figure 10). 2 employers reported that at most 60% of their workforce had less than 2 years of service, while 22 of the 35 employers reported that at least 60% of their workforce had tenure of more than 5 years at the same employer.

Figure 8: Distribution of Wood Species Being Processed in the Industry (based on 32 responses)

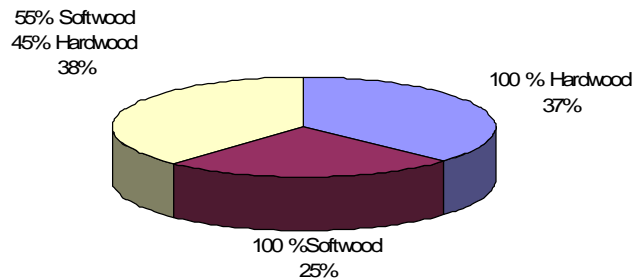


Figure 9: Age Distribution of the Workforce in the Sawmill Plywood/Veneer Industry

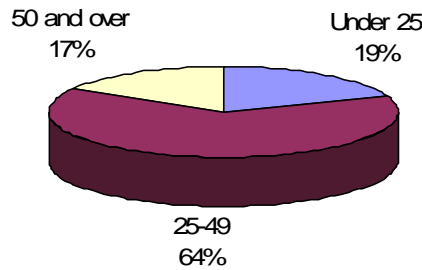
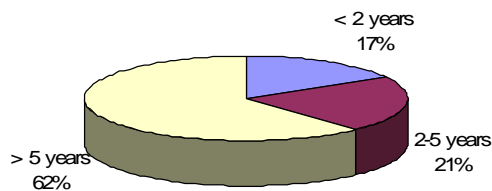


Figure 10: Years of Service for Sawmill Plywood/Veneer Industry Workforce



7.1.2 Hazards

In respect to anti-fungal or biological control agents in use within the industry, only 5 firms reported its use or presence in the workplace. Mycostat 3 was reported to be in use by 3 employers, along with Kathon 886 and C.C.A. The only designated substance reported by employers was arsenic and this was only indicated by one employer.

We asked participants about the existence of occupational health programs. In particular, we wanted to know what kinds of occupational health programs existed within the industry. This data was summarized below (see Table 8). The results show that more than 80% of the employers claim to administer some formal type of hearing conservation program, while less than 33% maintain either a respiratory protection program or a medical surveillance program.

Table 8: Available Occupational Health Programs

Type of Program	Responses		
	Yes	No	Unspecified
Hearing Conservation	29	6	0
Respiratory Protection	11	22	2
Medical Surveillance	11	21	3

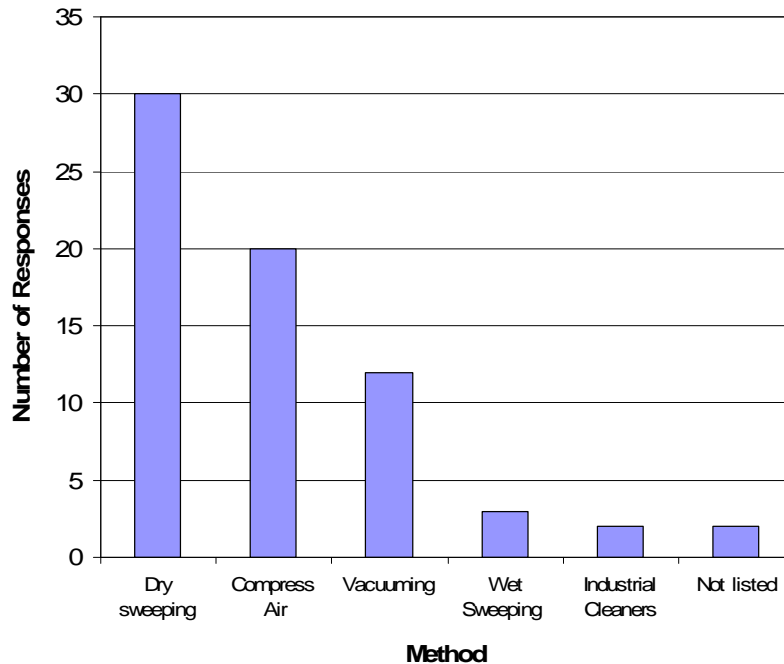
When asked whether wood dust, moulds, chemicals or noise were workplace hazards, 33 respondents (91%) said yes. Participants were also asked about hygiene monitoring or sampling. 22 said that they did sampling for noise, 18 said that they did sampling for wood dust, 10 said that they did sampling for chemicals, 4 said that they did sampling for mould, 4 said that they did sampling for other dusts, and 1 said that they did sampling for metals.

In respect to hazard controls, questions respecting ventilation, workplace hygiene and personal protective equipment were addressed.

Employers make use of a mix of natural ventilation, general ventilation and local exhaust ventilation is used by industry to control airborne dust or chemical hazards.

In respect to hygiene measures related to workplace clean up, the majority of employers claim to perform dry sweeping (30) or use compressed air (20) to clean the floors or machinery. 12 employers reported using vacuums for workplace cleanup (12) and surprisingly, only 3 employers reported using employed wet sweeping methods. 2 employers used industrial cleaners. 2 had no response (see Figure 11).

Figure 11: Cleanup Methods



Finally in terms of personal protective equipment, equipment use varied from employer to employer. Some type of respirator was claimed to be in use by 27 employers (77%). The most common type of respirator used was disposable (18) versus half-face cartridge (13). A smaller percentage of employers used full face or supplied air respirators. 9 employers (26%) claimed make use of more than one type of respirator.

A more detailed comparison of the 35 respondents that gave specific responses in both categories is shown in Table 9. Note that a blank response was treated as “no”. One responder was non specific in respect to what type of hazard existed, so it was assumed that they recognized all hazards listed.

The odds ratio of employers who perceive any respiratory hazards using ventilation versus employers who do not perceive respiratory hazards using ventilation is 15. The odds ratio of employers who perceive any respiratory hazards using any type of respirator versus employers who do not perceive respiratory hazards using respirators is 19. Finally the odds ratio of employers who perceive any chemical or biologic hazards using hand/skin protection versus employers who do not chemical/biologic hazards using skin protection is 8.

Table 9: Perceived Hazards in the Workplace (Comparison of Employers n=35)

Hazard	Protection		Perceived as Hazard	
	Type	Usage	No	Yes
Respiratory	Mechanical Ventilation	No	6	8
		Yes	1	20
	Respirator	No	7	7
		Yes	1	19
Chemical/Biological	Skin/Hand Protection	No	4	10
		Yes	1	20
Noise	Hearing Protection	No	1	11
		Yes	0	23

Finally, 17 of the 35 respondents indicated that they had made process improvements within the previous 3 years of the survey date. Of those 17, 10 reported a mild decrease in illnesses or health complaints resulting from the improvements. The other 7 respondents reported no change in complaints or illness. It should be noted that two of the respondents that reported minor improvements related to process changes, also reported an increase in complaints related to some other process changes.

We also questioned health and safety committee members or health and safety representatives about their opinions regarding occupational health and safety. They were asked about the level of risk in relation to the following hazards: chemicals, noise, wood dust, mould/fungus, other dust, or other health hazards. Risk was rated on a range of 1 (no risk) to 7 (very high risk).

A table showing the average response between health and safety reps (small firms), worker health and safety committee reps, and management health and safety committee reps is shown in the following Table 10.

Table 10: Mean Perceptions of Health Risks with respect to Health & Safety Representatives and Joint Health & Safety Worker or Management Representatives

Health Risks	HS Reps (n=10) Mean (Stdev)	JHSC Wrk Rep (n=21) Mean (Stdev)	JHSC Mgt Rep (n=21) Mean (Stdev)
Chemical Hazards	1.7 (1.1)	2.5 (1.6)	2.4 (1.3)
Noise Hazards	3.8 (1.8)	5.3 (1.2)	4.7 (1.2)
Wood Dust Hazards	3.3 (1.8)	5.2 (1.3)	4.4 (1.4)
Mould/Fungus Hazards	1.3 (0.5)	2.5 (1.1)	1.8 (0.6)
Other Dust Hazards	1.9 (1.6)	3.8 (1.9)	1.9 (0.8)
Other Health Hazards	1.2 (0.4)	3.7 (1.9)	2.7 (1.2)
General Overall Risk to Health	2.5 (1.1)	3.7(1.3)	3.2 (1.2)

The same respondents were asked to subjectively rank prevention of occupational disease and control of health hazards in the workplace in relation to other workplace issues such as employment, benefits, safety and economics. They were to rank this question from 1 to 7, with the lowest number implying not important and the highest number extremely important (see Table 11).

Table 11: Overall Priority Rating for Occupational Health

Representatives	n	Mean	(Std deviation)
Health & Safety	10	5.3	2.0
Joint Health & Safety Committee Worker	21	6.1	1.1
Joint Health & Safety Committee Management	21	5.5	1.2

Finally, when questioned about hazard investigations, the most frequent hazards investigated involved noise or wood dust, with slightly lower investigations reported for chemicals, mould/fungus or other dusts. Other less common issues investigated included yard dust, exhaust, formaldehyde, machine guarding, e coli bacterial, and carbon monoxide.

7.2 Observational (Walk-thru) Survey

The results of the walk-thru surveys at 22 different sites from 17 different companies for dust and noise are given in Table 12 (a) to Table 33(a). In these tables approximate percentages of wood types being processed are also indicated. Biotest results are given in corresponding tables and are denoted as Table (b) where such sampling was taken. Tables 34 to 50 are of various classifications of the entire data set of the 22 different sites. Classifications used are meeting room, outdoors, log yard, steam room, bailer, debarker, edger, trimmer, chipper, headrig/sawyer/band saw, resaw, planer, slasher, veneer plant, grading, boardway/green chain and filing room. Table 51 is a summary table of the similar locations of the 22 sites. This table has been denoted as (a) and (b). They contain the same data but have been sorted differently. Table 51(a) is based on data sorted on median noise from low values to high. Table 51(b) is based on data sorted on mean dust from low values to high.

Table 12(a): Site 01 — Noise and Dust Data of a Sawmill

LOCATION	RESULTS	
	NOISE (dB(A))	DUST(mg/m ³)
Training Room	69	0.200-0.300
Lumber Yard	80	0.01
Loading Debarker	87.7	0.005
Debarker Operator	85.7-96.0	0.47-1.60
Sawyer	96.0-103.0	0.670-1.50
Edger	97.2	0.75
Trimmer	103.1-105.2	0.630-1.070
Grader	96.3-101.0	0.030-1.150
Piler	77.9-96.3	0.200-0.300

Note: Biotest sampling not performed at this site.

Type of Wood Processed (approximate %): 95% Hardwood 5% Softwood

Table 13(a): Site 02 — Noise and Dust Data of a Plywood/Particleboard Plant

LOCATION	RESULTS	
	NOISE (dB(A))	DUST (mg/m ³)
Office	57	0.153
Outdoors, Parking Lot ^A	65.5	0.003
Slasher Cab	65.5	0.014-0.224
Slasher	76.0-80.0	0.032
Debarker Pond ^B	80	0.032
Debarker Cab	86.0-92.0	0.258-0.336
Pond Operator Cab	70.0-80.0	0.029
Pond, beside Cab	79.0-103	0.019
Lathe Operator Cab	79.0-81.0	0.028
Lathe Helper	90.0-100.0	0.035-0.046
Bull Edger		
Patching Machine #8	88.0-91.0	0.130-0.213
Chip and Saw	93.0-98.0	0.252-0.398
Stacker	97	0.494-0.656
Green Chain	92	0.433-0.560
Clipper		
Dryer/Feeder #2 ^C	85.0-89.0	0.669-0.758
Dry Chain Operator	86.9	0.285-0.308
Dry Stacker	89.0-95.0	0.301-0.698
VDA (Operator's Station/Scanner)	90	0.390-0.480
Ram Patch	89	0.484-0.611
Press #1 and #2	93	0.211-0.387
Glue Spreader #2	86.0-88.0	0.225-0.264
Glue Mixer	83.0-89.0	0.180-0.222
Kuper Operator	83.0-86.0	0.220-0.441
Press #3	82.0-91.0	0.190-0.303
Glue Spreader #4	76.0-81.0	0.097-0.266
Trim Saw Operator Station	93.0-95.0	0.300-0.800
Putty Line	82.0-84.0	0.054-0.215
Sander	90	0.119-0.345
Packaging	84.0-88.0	0.03-0.06
Grader Cab	77.0-79	0.046-0.135
Grader	86.0-89.0	0.093-0.123
Handyman Area	77	0.86-1.32

Note: Notations A, B & C correspond to sampling locations of Table 13(b).

Type of Wood Processed (approximate %): 98% Hardwood 2% Softwood

Table 13(b): Site 02 — Biotest Data of a Plywood/Particleboard Plant

	Location: Parking Lot ^A	Debarker ^B	Dryer Infeed ^C
Total Air Volume(Litres):	40	40	40
Detection Limit (CFU/m³):			
FUNGAL IDENTIFICATION:			
<i>Absidia sp.</i>	-	-	-
<i>Alternaria sp.</i>	-	+	-
<i>Cladosporium cladosporioides</i>	+	+	-
<i>Cladosporium herbarum</i>	-	-	-
<i>Geotrichum sp.</i>	-	-	-
<i>Mucor sp.</i>	-	-	-
<i>Penicillium subgenus Aspergilloides</i>	-		-
<i>Penicillium subgenus Penicillium</i>	+	+	+
<i>Rhizopus sp.</i>	-	-	-
<i>sterile mycelium</i>	+	-	+
<i>yeast</i>	-	+	+
TOTAL (CFU/m³):	<LOD	<LOD	<LOD

Note: Notations A, B & C correspond to sampling locations of Table 13(a).

Table 14(a): Site 03 — Noise and Dust Data of a Veneer Plant

LOCATION	RESULTS	
	NOISE (dB(A))	DUST (mg/m ³)
Conference Room	55.8	0
Parking Lot	59	0.016
Log Yard	70	0.04
Steam Vats	75	0.096
Bailer	85.0-90.0	0.427
Steam Room	92	0.026
Steam Room	97	0.026
Chipper/Hog Room ^A	102	0.511
Grinding Room	79	0.197
Log Deck, Debarking	92	0.21
Lathe Operator Station(1)	98.8	0.197
Debarking	95	0.266
Planer	92	0.288
Peeling	95.2	0.277
Peel Conveyor	93	0.31
Defect Station	89	0.273
Marking Station	88	0.153
Lunchroom ^B	65	0.089
Crate Room	100	0.027
Gluing	82	0.164
Splicer #1	84.1	0.247
Splicer Booth	80.4	0.214
Outdoors	69.8	0.161

Note: Notations A & B correspond to sampling locations of Table 14(b).

Type of Wood Processed (approximate %): 30% Hardwood 70% Softwood

Table 14(b): Site 03 — Biotest Data of a of a Veneer Plant

Location:	Chipper Room ^A	Lunch Room ^B
Total Air Volume(Litres):	80	80
Detection Limit (CFU/m³):	12.5	12.5
FUNGAL IDENTIFICATION:		
Absidia sp.		
Alternaria sp.	-	38
Cladosporium cladosporioides	500	375
Cladosporium herbarum	250	250
Geotrichum sp.	-	-
Mucor sp.	-	-
Penicillium subgenus Aspergilloides	-	-
Penicillium subgenus Penicillium	413	325
Rhizopus sp.	13	-
sterile mycelium	-	125
yeast	250	188
TOTAL (CFU/m³):	1426	1301

Note: Notations A & B correspond to sampling locations of Table 14(a).

Table 15(a): Site 04 — Noise and Dust Data of a Sawmill

LOCATION	RESULTS	
	NOISE (dB(A))	DUST (mg/m ³)
Debarker Cab	86	0.7
Debarker Cab	73.3	0.047
Head Rig Cab	80	0.2
Head Rig	100.9	0.312
Re-Saw ^A	103	2.8
Trimmerman #1	97.7	0.53
Trimmerman #2/Grader	98.3	0.346
Edger	106	1.12
Boardway	67.7	0.055
Filing Room	77.9	0.034
Outdoors, beside Sawmill Office	64	0.041
Office ^B	68	0.36
Chipper	107.8	0.829

Note: Notations A & B correspond to sampling locations of Table 15(b).

Type of Wood Processed (approximate %): 100% Hardwood 0% Softwood

Table 15(b): Site 04 — Biotest Data of a Sawmill

Location:	Resaw ^A	Office ^B
Total Air Volume(Litres):	40	40
Detection Limit (CFU/m³):	25	25
FUNGAL IDENTIFICATION:		
<i>Absidia sp.</i>	-	-
<i>Alternaria sp.</i>	-	-
<i>Cladosporium cladosporioides</i>	275	25
<i>Cladosporium herbarum</i>	-	-
<i>Geotrichum sp.</i>	-	-
<i>Mucor sp.</i>	25	-
<i>Penicillium subgenus Aspergilloides</i>	-	-
<i>Penicillium subgenus Penicillium</i>	550	150
<i>Rhizopus sp.</i>	-	-
<i>sterile mycelium</i>	-	325
<i>yeast</i>	725	425
TOTAL (CFU/m³):	1575	925

Note: Notations A & B correspond to sampling locations of Table 15(a).

Table 16(a): Site 05 — Noise and Dust Data of a Sawmill/Planer Mill

LOCATION	RESULTS	
	NOISE (dB(A))	DUST (mg/m ³)
Meeting Room, Main Office	57	0.015
Parking Lot	69	0.023
Debarker Outfeed	70	0.032
Log Yard	69	0.019
Debarker Cab	69	0.753
Chipper/Slash Booth	100	2.49
Debarker Cab, 18 inch	80	1.35
Debarker Cab, 30 inch ^A	75	1.72
Debarker, 30 inch	96	3.43
Filing Room	99	2
Filing Room	79	1.28
VDA Area/Scanning	95	3.55
Trimmer	92	2.25
Edger	91	1.21
Edger	96	1.19
Trimmer	97	2.1
Chipper	111	1.42
Chipper Booth	94	0.89
Boardway	97	0.149
Sorter	99	0.105
Stacker	97	0.25
Planer	100	0.22
Trimmer/Grader	96	0.306
Dropping Station	88	0.051
Office, behind Mill ^B	71	0.025

Note: Notations A & B correspond to sampling locations of Table 16(b).

Type of Wood Processed (approximate %): 0% Hardwood 100% Softwood

Table 16(b): Site 05 — Biotest Data of a Sawmill/Planer Mill

Location:	Debarker ^A	Office ^B
Total Air Volume(Litres):	80	80
Detection Limit (CFU/m³):	12.5	12.5
FUNGAL IDENTIFICATION:		
<i>Absidia sp.</i>		
<i>Alternaria sp.</i>	-	125
<i>Cladosporium cladosporioides</i>	1250	63
<i>Cladosporium herbarum</i>	-	25
<i>Geotrichum sp.</i>	-	-
<i>Mucor sp.</i>	-	-
<i>Penicillium subgenus Aspergilloides</i>	-	-
<i>Penicillium subgenus Penicillium</i>	2500	138
<i>Rhizopus sp.</i>	-	-
<i>sterile mycelium</i>	250	100
<i>yeast</i>	625	25
TOTAL (CFU/m³):	4625	476

Note: Notations A & B correspond to sampling locations of Table 16(a).

Table 17(a): Site 06 — Noise and Dust Data of a Scrag Mill

LOCATION	RESULTS	
	NOISE (dB(A))	DUST (mg/m ³)
Ring Debarker Cab	73	0.7
Ring Debarker	95.7	1.01
Twin Saws	72.8	0.348
Bull Edger(/Re-Saw	94.0-97	1.45
Tailer/Trimmer ^A	94.8	1.54
Green Chain	71.8	0.445

Note: Notation A corresponds to sampling location of Table 17(b).

Type of Wood Processed (approximate %): 55% Hardwood 45% Softwood

Table 17(b): Site 06 — Biotest Data of a Scrag Mill

Location:	Tailer/Trimmer ^A
Total Air Volume(Litres):	40
Detection Limit (CFU/m³):	25
FUNGAL IDENTIFICATION:	
<i>Absidia sp.</i>	-
<i>Alternaria sp.</i>	-
<i>Cladosporium cladosporioides</i>	100
<i>Cladosporium herbarum</i>	-
<i>Geotrichum sp.</i>	-
<i>Mucor sp.</i>	-
<i>Penicillium subgenus Aspergilloides</i>	-
<i>Penicillium subgenus Penicillium</i>	125
<i>Rhizopus sp.</i>	-
<i>sterile mycelium</i>	-
<i>yeast</i>	1075
TOTAL (CFU/m³):	1300

Note: Notation A corresponds to sampling locations of Table 17(a).

Table 18(a): Site 07 — Noise and Dust Data of a Log Mill

LOCATION	RESULTS	
	NOISE (dB(A))	DUST (mg/m ³)
Debarker Cab	85	0.08
Sawyer Cab	85	0.3
Sawyer	102	0.249
Bull Edger	98.6	0.386
Trimmerman #1	96.8	0.326
Trimmerman #2	98.4	0.575
Boardway	82	0.107
Pilers	69.3	0.046
Office ^A	56.8	0.047

Note: Notation A corresponds to sampling location of Table 18(b).

Type of Wood Processed (approximate %): 55% Hardwood 45% Softwood

Table 18(b): Site 07 — Biotest Data of a Log Mill

Location:	Office ^A
Total Air Volume(Litres):	40
Detection Limit (CFU/m ³):	25
FUNGAL IDENTIFICATION:	
<i>Absidia sp.</i>	-
<i>Alternaria sp.</i>	-
<i>Cladosporium cladosporioides</i>	-
<i>Cladosporium herbarum</i>	100
<i>Geotrichum sp.</i>	-
<i>Mucor sp.</i>	-
<i>Penicillium subgenus Aspergilloides</i>	-
<i>Penicillium subgenus Penicillium</i>	-
<i>Rhizopus sp.</i>	-
sterile mycelium	75
yeast	50
TOTAL (CFU/m³):	225

Note: Notation A corresponds to sampling locations of Table 18(a).

Table 19(a): Site 08 — Noise and Dust Data of a Scrag Mill

LOCATION	RESULTS	
	NOISE (dB(A))	DUST (mg/m ³)
Outdoors, beside Weigh Scale ^A	68	0.005
Outdoors, beside Weigh Scale	58	0.005
Debarker	96	0.221
Sawyer	70	0.053
Bull Edger	95	0.721
Edgers	97	0.615
Green Chain	92	0.18
Trimmer	92.5	0.62
Sorter	83.4	0.154
Stacker	91	0.121
Filing Room	78	0.407

Note: Notation A corresponds to sampling location of Table 19(b).

Type of Wood Processed (approximate %): 35% Hardwood 65% Softwood

Table 19(b): Site 08 — Biotest Data of a Scrag Mill

Location:	Outdoors^A
Total Air Volume(Litres):	40
Detection Limit (CFU/m³):	25
FUNGAL IDENTIFICATION:	
<i>Absidia sp.</i>	-
<i>Alternaria sp.</i>	-
<i>Cladosporium cladosporioides</i>	25
<i>Cladosporium herbarum</i>	-
<i>Geotrichum sp.</i>	-
<i>Mucor sp.</i>	-
<i>Penicillium subgenus Aspergilloides</i>	-
<i>Penicillium subgenus Penicillium</i>	-
<i>Rhizopus sp.</i>	-
<i>sterile mycelium</i>	-
<i>yeast</i>	150
TOTAL (CFU/m³):	175

Note: Notation A corresponds to sampling locations of Table 19(a).

Table 20(a): Site 09 — Noise and Dust Data of a Log Mill

LOCATION	RESULTS	
	NOISE (dB(A))	DUST (mg/m ³)
Outdoors, Parking Lot beside Scale House	68.1	0.008
Debarker Cab	90	0.055
Sawyer Cab	75	0.053
Edger	98	0.207
Re-Saw ^A	100.3	0.394
Trimmerman #1	98.9	0.319
Trimmerman #2	100.4	0.15
Boardway	76.5	0.066

Note: Notation A corresponds to sampling location of Table 20(b).

Type of Wood Processed (approximate %): 35% Hardwood 65% Softwood

Table 20(b): Site 09 — Biotest Data of a Log Mill

Location:	Re-Saw ^A
Total Air Volume(Litres):	40
Detection Limit (CFU/m³):	25
FUNGAL IDENTIFICATION:	
<i>Absidia sp.</i>	-
<i>Alternaria sp.</i>	-
<i>Cladosporium cladosporioides</i>	50
<i>Cladosporium herbarum</i>	-
<i>Geotrichum sp.</i>	-
<i>Mucor sp.</i>	-
<i>Penicillium subgenus Aspergilloides</i>	-
<i>Penicillium subgenus Penicillium</i>	100
<i>Rhizopus sp.</i>	-
<i>sterile mycelium</i>	-
<i>yeast</i>	325
TOTAL (CFU/m³):	475

Note: Notation A corresponds to sampling locations of Table 20(a)

Table 21(a): Site 10 — Noise and Dust Data of a Sawmill/Planer Mill

LOCATION	RESULTS	
	NOISE (dB(A))	DUST (mg/m ³)
Training Room	61.3	0.013
Warehouse,	73.9	0.057
Parking Lot	71.5-78.4	0.032
North-West Log Yard	82	0.033
Filing Room	83.1-92.1	0.033-0.114
Debarking	98	0.038-0.073
Bandsaw	95.4-100.00	0.073-0.255
Vat Loading Area	91.7-93.4	0.039-0.063
Planer	92.4-97.9	0.061-0.212
Slicer	94.8	0.54
Slicer, Operator's station	95.1	0.155
Peeler	91.3-96.9	0.073
Peeler	92.8-98.0	0.077-0.205
Dryer Feed	92.0-93.6	0.093-0.132
Dryer Outfeed	91.6-92.7	0.077-0.105
Clipper #1	90.2-94.2	0.061-0.105
Clipper #2	90.8-93.7	0.073-0.088
Bundle Conveyor	77.6-80.1	0.061-0.092
Forklift Area	79.0-84.9	0.069-0.097
Splicer/Glue Area	74.0-80.9	0.054-0.151

Note: Biotest sampling not performed at this site.

Type of Wood Processed (approximate %): 98% Hardwood 2% Softwood

Table 22(a): Site 11 — Noise and Dust Data of a Sawmill

LOCATION	RESULTS	
	NOISE (dB(A))	DUST (mg/m ³)
Parking Lot	71.5	0.1
Office	71.5	0.1
Debarker	89.1	0.200-0.600
Filer Room	76.6-92.5	0.2
Edger	93.0-99.8	0.200-5.60
Strippers	103.3-107.9	3.000-7.800
Graders	99.0-107.0	0.8
Loading Area	83.8-94.9	0.6

Note: Biotest sampling not performed at this site.

Type of Wood Processed (approximate %): 100% Hardwood 0% Softwood

Table 23(a): Site 12 — Noise and Dust Data of a Band Mill

LOCATION	RESULTS	
	NOISE (dB(A))	DUST (mg/m ³)
Debarker Cab	77	0.05
Sawyer Cab	77	0.13
Sawyer	99	0.075
Tail Sawyer, #2 side	97	0.529
Tail Sawyer, #1 side ^A	98	0.847
Re-Saw	100	1.3
Re-Saw, Jacking wood	103	0.82
Edger #1	97.9	0.864
Edger #2	100.9	1.01
Chipper	103.8	0.567
Trimmer, right side of line	100	0.704
Trimmer, left side of line	100	0.647
Grader	70	0.128
Office	60	0.02

Note: Notation A corresponds to sampling location of Table 23(b).

Type of Wood Processed (approximate %): 40% Hardwood 60% Softwood

Table 23(b): Site 12 — Biotest Data of a Band Mill

Location:	Tail Sawyer#1 ^A
Total Air Volume(Litres):	40
Detection Limit (CFU/m³):	25
FUNGAL IDENTIFICATION:	
<i>Absidia sp.</i>	-
<i>Alternaria sp.</i>	-
<i>Cladosporium cladosporioides</i>	650
<i>Cladosporium herbarum</i>	-
<i>Geotrichum sp.</i>	-
<i>Mucor sp.</i>	-
<i>Penicillium subgenus Aspergilloides</i>	-
<i>Penicillium subgenus Penicillium</i>	1050
<i>Rhizopus sp.</i>	50
<i>sterile mycelium</i>	-
<i>yeast</i>	950
TOTAL (CFU/m³):	2700

Note: Notation A corresponds to sampling locations of Table 23(a).

Table 24(a): Site 13 — Noise and Dust Data of a Scrag Mill

LOCATION	RESULTS	
	NOISE (dB(A))	DUST (mg/m ³)
Debarker	96.8	1.37
Sawyer Cab	92	0.9
Sawyer	102	1.33
Re-Saw	101	1.25
Re-Saw Tailer	100.9	0.817
Bull/Board Edger	98.6	0.759
End Trimming	99.3	0.965
Chipper	98.5	0.056
Boardway	86.8	0.415
Outdoors, beside Main Office ^A	75	0.015

Note: Notation A corresponds to sampling location of Table 24(b).

Type of Wood Processed (approximate %): 40% Hardwood 60% Softwood

Table 24(b): Site 13 — Biotest Data of a Scrag Mill

Location:	Outdoors ^A
Total Air Volume(Litres):	40
Detection Limit (CFU/m ³):	25
FUNGAL IDENTIFICATION:	
<i>Absidia sp.</i>	-
<i>Alternaria sp.</i>	-
<i>Cladosporium cladosporioides</i>	-
<i>Cladosporium herbarum</i>	50
<i>Geotrichum sp.</i>	-
<i>Mucor sp.</i>	-
<i>Penicillium subgenus Aspergilloides</i>	-
<i>Penicillium subgenus Penicillium</i>	50
<i>Rhizopus sp.</i>	-
sterile mycelium	25
yeast	75
TOTAL (CFU/m³):	200

Note: Notation A corresponds to sampling locations of Table 24(a).

Table 25(a): Site 14 — Noise and Dust Data of a Planer Mill

LOCATION	RESULTS	
	NOISE (dB(A))	DUST (mg/m ³)
Re-Saw	104	0.323
Planer/Feeder	109	0.027
Grader/Trim Saw	104	0.334

Note: Biotest sampling not performed at this site.

Type of Wood Processed (approximate %): 40% Hardwood 60% Softwood

Table 26(a): Site 15 — Noise and Dust Data of a Plywood Plant

LOCATION	RESULTS	
	NOISE (dB(A))	DUST (mg/m ³)
Meeting Room	62	0.04
Parking Lot, edge of Log Yard	65	0.105
Log Yard	68	0.035
Trimmer/Debarker Cab(1)	70	0.051
Pondman	87	0.142
Swing Saw Cab	83	0.278
Swing Saw	95	0.642
4 ft. Lathe Operator Booth	84	0.178
8 ft. Lathe Operator Booth	84	0.137
Filing Room	93	0.3
Trimmer/Debarker	86	0.074
Core Saw Operator Station	93	0.236
Chip Line	107	0.063-0.495
Chipper Room	107	0.771
Chipper Room	107	0.56
Batcher Area	94	0.852-1.492
Beside 8 ft. Lathedust collector bags	95	0.137
Beside 4 ft. Lathe dust collector bags	94	0.094
8 ft. Dryer	88	0.208
Beside Kilns	91	2.26
8 ft. Discharge Station	91	0.324
4 ft. Discharge Station	88	0.815
4 ft. Dryer Feed	95	0.105
Warehouse ^A	82	0.162
4 ft. Glue Machine	84	0.079
Rip Saw	94	0.116-0.152
Core Composer	95	0.254
Sanding Line	93	0.302
Grading Booth	80	0.282
Grading Booth	75	0.35
Outdoors	67	0.055

Note: Notation A corresponds to sampling location of Table 26(b).

Type of Wood Processed (approximate %): 100% Hardwood 0% Softwood

Table 26(b): Site 15 — Biotest Data of a Plywood Plant

Location:	Warehouse^A
Total Air Volume(Litres):	80
Detection Limit (CFU/m³):	12.5
FUNGAL IDENTIFICATION:	
<i>Absidia sp.</i>	
<i>Alternaria sp.</i>	88
<i>Cladosporium cladosporioides</i>	100
<i>Cladosporium herbarum</i>	25
<i>Geotrichum sp.</i>	-
<i>Mucor sp.</i>	13
<i>Penicillium subgenus Aspergilloides</i>	86
<i>Penicillium subgenus Penicillium</i>	100
<i>Rhizopus sp.</i>	-
<i>sterile mycelium</i>	38
<i>yeast</i>	88
TOTAL (CFU/m³):	540

Note: Notation A corresponds to sampling locations of Table 26(a).

Table 27(a): Site 16 — Noise and Dust Data of a Planer Mill

LOCATION	RESULTS	
	NOISE (dB(A))	DUST (mg/m ³)
Pete Van Amelsfoort's Office	59	0.03
Parking Lot	77.7	0.021-0.035
Kiln Area	72.5	0.038
Kiln #4	78.3	0.027
Grading Line ^A	84.0-92.0	0.073
Stacking Line ^B	88	0.052-0.223

Note: Notations A & B correspond to sampling locations of Table 27(b).

Type of Wood Processed (approximate %): 95% Hardwood 5% Softwood

Table 27(b): Site 16 — Biotest Data of a Planer Mill

Location:	Grading ^A	Stacking ^B
Total Air Volume(Litres):	80	80
Detection Limit (CFU/m³):	12.5	12.5
FUNGAL IDENTIFICATION:		
<i>Absidia sp.</i>		
<i>Alternaria sp.</i>	-	-
<i>Cladosporium cladosporioides</i>	50	188
<i>Cladosporium herbarum</i>	38	-
<i>Geotrichum sp.</i>	-	-
<i>Mucor sp.</i>	-	-
<i>Penicillium subgenus Aspergilloides</i>	-	-
<i>Penicillium subgenus Penicillium</i>	175	100
<i>Rhizopus sp.</i>	-	-
<i>sterile mycelium</i>	50	50
<i>yeast</i>	25	63
TOTAL (CFU/m³):	338	401

Note: A & B notations correspond to sampling locations of Table 27(a).

Table 28(a): Site 17 — Noise and Dust Data of a Sawmill/Planer Mill

LOCATION	RESULTS	
	NOISE (dB(A))	DUST (mg/m ³)
Machine Shop/Filing Room	82	0.043-0.078
Slasher Cab(1)	69.0-71.0	0.009-0.079
Slasher	97	0.004
Debarker Cab(1)	72	0.062-0.114
Debarker ^{A, B} (below debarker)	89.0-91.0	0.144-0.238
Log Deck(1)	101	0.091-0.236
Small Slasher(1)	89.0-92.0	0.085-0.157
Band Saw	68	0.025-0.056
Edger/Chipper Cab(1)	76.0-79.0	0.028-0.044
Edger/Chipper Cab	93.0-95.0	0.090-0.149
Go Back Area	94.0-96.0	0.054-0.129
Chipper Cab(1)	80.0-82.0	0.128-0.168
Chipper Cab	97.0-105.0	0.498-2.27
Stacker	95	0.012-0.410
Strapper	84.0-90.0	0.004-0.016
Planer Mill, Tilt Hoist	96.0-98.0	0.034-0.980
Planer Mill, Planer Feeder(1)	104	0.170-0.994
Planer Mill, Grader(1)	95	0.138-0.607
Planer Mill, Lift/Skid/Slip Area	96.0-98.0	0.455-1.14
Planer Mill, Stacker(1)	98.0-103.0	0.088-0.479
Planer Mill, Strapping/Packaging	80.0-88.0	0.085-0.222

Note: Notations A & B correspond to sampling locations of Table 28(b).

Type of Wood Processed (approximate %): 0% Hardwood 100% Softwood

Table 28(b): Site 17 — Biotest Data of a Sawmill/Planer Mill

Location:	Debarker ^A	Below Debarker ^B	Outdoors
Total Air Volume(Litres):	40	40	40
Detection Limit (CFU/m ³):			
FUNGAL IDENTIFICATION:			
<i>Absidia sp.</i>	+	-	-
<i>Alternaria sp.</i>	-	-	-
<i>Cladosporium cladosporioides</i>	+	-	-
<i>Cladosporium herbarum</i>	-	-	-
<i>Geotrichum sp.</i>	-	-	-
<i>Mucor sp.</i>	-	+	-
<i>Penicillium subgenus Aspergilloides</i>	-	-	-
<i>Penicillium subgenus Penicillium</i>	+	+	+
<i>Rhizopus sp.</i>	-	-	-
sterile mycelium	-	-	+
yeast	+	-	-
TOTAL (CFU/m³):	<LOD	<LOD	<LOD

Note: Notations A & B correspond to sampling locations of Table 28(a).

Table 29(a): Site 18 — Noise and Dust Data of a Sawmill

LOCATION	RESULTS	
	NOISE (dB(A))	DUST (mg/m ³)
Outdoors, beside Safety Coordinator Office ^A	72-76	0.002
Calvin's Office	65	0.107
Chipper	108	0.289
Debarker Booth	95	0.18
Between Re-Saw and Head Saw ^B	100	0.395
Head Saw Operator Booth	75.9	0.099
Bull Edger	98	0.748
Re-Saw Tail/Edger	95	0.18

Note: Notations A & B correspond to sampling locations of Table 29(b).

Type of Wood Processed (approximate %): 100% Hardwood 0% Softwood

Table 29(b): Site 18 — Biotest Data of a Sawmill

Location:	Outdoors ^A	Head Saw ^B
Total Air Volume(Litres):	40	40
Detection Limit (CFU/m³):	25	25
FUNGAL IDENTIFICATION:		
<i>Absidia sp.</i>	-	-
<i>Alternaria sp.</i>	-	-
<i>Cladosporium cladosporioides</i>	-	7500
<i>Cladosporium herbarum</i>	25	-
<i>Geotrichum sp.</i>	-	-
<i>Mucor sp.</i>	-	250
<i>Penicillium subgenus Aspergilloides</i>	-	-
<i>Penicillium subgenus Penicillium</i>	25	1425
<i>Rhizopus sp.</i>	-	-
<i>sterile mycelium</i>	75	-
<i>yeast</i>	25	5000
TOTAL (CFU/m³):	150	14175*

Note: * Sample overloaded. Reported CFU count is estimated.

Note: Notations A & B correspond to sampling locations of Table 29(a).

Table 30(a): Site 19 — Noise and Dust Data of a Flooring Plant

LOCATION	RESULTS	
	NOISE (dB(A))	DUST (mg/m ³)
Centre of Plant	92	0.367
Lumber Hoist	91.4	0.715
Rip Saw	95.7	0.535
Rough Knot Saw	92	0.367
Sorting Table	95	0.37
Planer ^A	107	0.585
Finish Knot Saw	91.9	0.466
End Matcher	90.2	0.315
Outdoors, beside Safety Coordinator Office	76	0.02

Note: Notation A corresponds to sampling location of Table 30(b).

Type of Wood Processed (approximate %): 100% Hardwood 0% Softwood

Table 30(b): Site 19 — Biotest Data of a Flooring Plant

Location:	Planer ^A
Total Air Volume(Litres):	40
Detection Limit (CFU/m ³):	25
FUNGAL IDENTIFICATION:	
<i>Absidia sp.</i>	-
<i>Alternaria sp.</i>	-
<i>Cladosporium cladosporioides</i>	75
<i>Cladosporium herbarum</i>	50
<i>Geotrichum sp.</i>	-
<i>Mucor sp.</i>	-
<i>Penicillium subgenus Aspergilloides</i>	-
<i>Penicillium subgenus Penicillium</i>	50
<i>Rhizopus sp.</i>	25
sterile mycelium	-
yeast	175
TOTAL (CFU/m³):	375

Note: Notation A corresponds to sampling location of Table 30(a).

Table 31(a): Site 20 — Noise and Dust Data of a Sawmill/Planer Mill

LOCATION	RESULTS	
	NOISE (dB(A))	DUST (mg/m ³)
Log Yard (Outdoors) ^A	66	0.039
Baghouse(outside)	78.9	0.013-0.398
Slasher Cab	79	0.04-0.346
Slasher, beside Cab	93.0-101.0	0.276-0.560
Debarker, beside Cab	93	0.66
Debarker Cab	72	0.067-0.268
Debarker Helper ^B	97	0.441-1.07
Scanner#2 and #3	78	0.130-0.215
Chipper Cab	78	0.011-0.046
Chipper, beside Cab	93	0.050-0.109
Canter #1 Cab	70	0.053-0.369
Canter, beside Cab	93	0.147-0.235
Canter #2	98.5	0.367-0.641
Compactor Cab	70	0.100-0.330
Reman	96	0.295-0.424
Trimmer	94	0.100-0.501
Bin Sorter	98	0.055-0.133
Stacker	95	0.077-0.220
Kiln Operator Booth	69	0.023-0.189
Refuse Truck Operator's Office ^C	64.5	0.022-0.126
Planer Mill Infeed	98	0.061-0.495
Planer Mill, Hand Piling	95.6	0.128-0.386
Planer Mill, Dunnage Cutter	95.6	0.101-0.229
Planer Mill, Planer	97	0.108-0.652
Planer Mill, Stud Stacker	97	0.116-0.309
Planer Mill, Economy Stacker	93	0.051-0.231
Planer Mill, Strapper	88.4	0.005
Planer Mill, Planer Room	117	0.007-0.312

Note: Notations A, B & C correspond to sampling locations of Table 31(b).

Type of Wood Processed (approximate %): 0% Hardwood 100% Softwood

Table 31(b): Site 20 — Biotest Data of a Sawmill/Planer Mill

Location:	Outdoors ^A	Debarker Helper ^B	Refuse Truck Office ^C
Total Air Volume(Litres):	40	40	40
Detection Limit (CFU/m ³):			
FUNGAL IDENTIFICATION:			
<i>Absidia sp.</i>	-	-	-
<i>Alternaria sp.</i>	-	-	-
<i>Cladosporium cladosporioides</i>	+	+	+
<i>Cladosporium herbarum</i>	-	-	-
<i>Geotrichum sp.</i>	-	-	-
<i>Mucor sp.</i>	+	+	+
<i>Penicillium subgenus Aspergilloides</i>	-	-	-
<i>Penicillium subgenus Penicillium</i>	+	+	+
<i>Rhizopus sp.</i>	-	-	-
<i>sterile mycelium</i>	-	-	-
<i>yeast</i>	+	+	+
TOTAL (CFU/m³):	<LOD	<LOD	<LOD

Note: Notations A , B & C correspond to sampling locations of Table 31(a).

Table 32(a): Site 21 — Noise and Dust Data of a Sawmill

LOCATION	RESULTS	
	NOISE (dB(A))	DUST (mg/m ³)
Safety Coordinator Office	57	0.041
Warehouse	50	0.076
Debarker	86	0.029
Band Saw	94	0.033
Resaw	94	0.083
Edger #1	94	0.061
Edger #2 ^A	95	1.318
Chipper	101	0.419
Trimmer	99	0.389
Boardway/Stacking	86	0.339
Secondary Storage Area ^B	59.6-70.1	0.01

Note: Notations A & B correspond to sampling locations of Table 32(b).

Type of Wood Processed (approximate %): 60% Hardwood 40% Softwood

Table 32(b): Site 21 — Biotest Data of a Sawmill

Location:	Edger ^A	Secondary Storage ^B
Total Air Volume(Litres):	80	80
Detection Limit (CFU/m³):	12.5	12.5
FUNGAL IDENTIFICATION:		
<i>Absidia sp.</i>		
<i>Alternaria sp.</i>	-	-
<i>Cladosporium cladosporioides</i>	288	288
<i>Cladosporium herbarum</i>	---	75
<i>Geotrichum sp.</i>	75	-
<i>Mucor sp.</i>	-	-
<i>Penicillium subgenus Aspergilloides</i>	-	-
<i>Penicillium subgenus Penicillium</i>	313	113
<i>Rhizopus sp.</i>	-	-
<i>sterile mycelium</i>	-	50
<i>yeast</i>	263	13
TOTAL (CFU/m³):	939	539

Note: Notations A & B correspond to sampling locations of Table 32(a).

Table 33(a): Site 22 — Noise and Dust Data of a Sawmill/Planer Mill

LOCATION	RESULTS	
	NOISE (dB(A))	DUST (mg/m ³)
Mill Office	75.1	0.086
Debarker	89.5	0.112-0.134
Head Cutter	81.8-99.1	0.110-0.170
Filing Room	85.0-96.7	0.137-0.923
Filer	83.4-105.2	0.817-0.837
Resaw	102.1-103.3	0.353-0.551
Edger	100.7-106.3	0.392-0.516
Trim Saw	98.1-98.5	0.127-0.779
Green Chain	89.3-98.5	0.120-0.189
Kiln	81.3-86.1	0.141-0.142
Ripsaw	93.0-102.9	0.117-0.190
Planer #1	101.4-107.2	0.122-0.227
Planer #2	102.8-107.2	0.208-0.227
Piler	85.2-99.7	0.126-0.167
Grading Line	92.8-97.9	0.097-0.112
Ripper	84.8-98.0	0.090-0.122
Ripsaw Area	94.5-98.0	0.155-0.169
Hardwood Cutting	76.8-94.3	0.135-0.272

Note: Biotest sampling not performed at this site.

Type of Wood Processed (approximate %): 95% Hardwood 5% Softwood

Table 34: Meeting Room – Compiled Data of the 22 Sites
(refer to particular Site ID for Biotest Results)

ID	LOCATION	RESULTS		
		NOISE (dB(A))	DUST (mg/m ³)	BIOTEST Done
Site 01	Training Room	69	0.200-0.300	
Site 02	Office	57	0.153	
Site 03	Conference Room	55.8	0	
Site 04	Office	68	0.36	✓
Site 05	Meeting Room, Main Office	57	0.015	
Site 07	Office	56.8	0.047	✓
Site 10	Training Room	61.3	0.013	
Site 11	Office	71.5	0.1	
Site 12	Office	60	0.02	
Site 15	Meeting Room	62	0.04	
Site 16	Office	59	0.03	
Site 18	Office	65	0.107	
Site 20	Refuse Truck Operator's Office	64.5	0.022-0.126	✓
Site 21	Office	57	0.041	
Site 22	Mill Office	75.1	0.086	

Table 35: Outdoors – Compiled Data of the 22 Sites
(refer to particular Site ID for Biotest Results)

ID	LOCATION	RESULTS		
		NOISE (dB(A))	DUST (mg/m ³)	BIOTEST Done
Site 02	Outdoors, beside Door F-3	65.5	0.003	✓
Site 03	Parking Lot	59	0.016	
Site 05	Parking Lot	69	0.023	
Site 05	Office, behind Mill	71	0.025	✓
Site 08	Outdoors, beside Weigh Scale	68	0.005	✓
Site 08	Outdoors, beside Weigh Scale	58	0.005	
Site 09	Outdoors, Parking Lot beside Scale House	68.1	0.008	
Site 10	Parking Lot	71.5-78.4	0.032	
Site 13	Outdoors, beside Main Office	75	0.015	✓
Site 15	Parking Lot, edge of Log Yard	65	0.105	
Site 15	Outdoors	67	0.055	
Site 16	Parking Lot	77.7	0.021-0.035	
Site 18	Outdoors, beside Safety Coordinator Office	72-76	0.002	✓
Site 19	Outdoors, beside Safety Coordinator Office	76	0.02	

Table 36: Log Yard – Compiled Data of the 22 Sites
(refer to particular Site ID for Biotest Results)

ID	LOCATION	RESULTS		
		NOISE (dB(A))	DUST (mg/m ³)	BIOTEST Done
Site 01	Lumber Yard	80	0.01	
Site 03	Log Yard	70	0.04	
Site 05	Log Yard	69	0.019	
Site 10	North-West Log Yard	82	0.033	
Site 15	Log Yard	68	0.035	
Site 20	Log Yard	66	0.039	✓

Table 37: Steam Room – Compiled Data of the 22 Sites
(refer to particular Site ID for Biotest Results)

ID	LOCATION	RESULTS		
		NOISE (dB(A))	DUST (mg/m ³)	BIOTEST Done
Site 03	Steam Vats	75	0.096	
Site 03	Steam Room	92	0.026	
Site 03	Steam Room	97	0.026	

Table 38: Bailer – Compiled Data of the 22 Sites
(refer to particular Site ID for Biotest Results)

ID	LOCATION	RESULTS		
		NOISE (dB(A))	DUST (mg/m ³)	BIOTEST Done
Site 03	Bailer	85.0-90.0	0.427	

Table 39: Debarker – Compiled Data of the 22 Sites
(refer to particular Site ID for Biotest Results)

ID	LOCATION	RESULTS		
		NOISE (dB(A))	DUST (mg/m ³)	BIOTEST Done
Site 01	Loading Debarker	87.7	0.005	
Site 01	Debarker Operator	85.7-96.0	0.47-1.60	
Site 02	Debarker Pond	80	0.032	✓
Site 02	Debarker Cab	86.0-92.0	0.258-0.336	
Site 03	Debarking	95	0.266	
Site 04	Debarker Cab	86	0.7	
Site 04	Debarker Cab	73.3	0.047	
Site 05	Debarker Outfeed	70	0.032	
Site 05	Debarker Cab	69	0.753	
Site 05	Debarker Cab, 18 inch	80	1.35	
Site 05	Debarker Cab, 30 inch	75	1.72	✓
Site 05	Debarker, 30 inch	96	3.43	
Site 06	Ring Debarker Cab	73	0.7	
Site 06	Ring Debarker	95.7	1.01	
Site 07	Debarker Cab	85	0.08	
Site 08	Debarker	96	0.221	
Site 09	Debarker Cab	90	0.055	
Site 10	Debarking	98	0.038-0.073	
Site 11	Debarker	89.1	0.200-0.600	
Site 12	Debarker Cab	77	0.05	
Site 13	Debarker	96.8	1.37	
Site 15	Trimmer/Debarker Cab(1)	70	0.051	
Site 17	Debarker Cab(1)	72	0.062-0.114	
Site 17	Debarker	89.0-91.0	0.144-0.238	✓
Site 17	Debarker			✓
Site 17	Log Deck(1)	101	0.091-0.236	
Site 18	Debarker Booth	95	0.18	
Site 20	Debarker, beside Cab	93	0.66	
Site 20	Debarker Cab	72	0.067-0.268	
Site 20	Debarker Helper	97	0.441-1.07	✓
Site 21	Debarker	86	0.029	
Site 22	Debarker	89.5	0.112-0.134	

Table 40: Edger – Compiled Data of the 22 Sites
 (refer to particular Site ID for Biotest Results)

ID	LOCATION	RESULTS		
		NOISE (dB(A))	DUST (mg/m ³)	BIOTEST Done
Site 01	Edger	97.2	0.75	
Site 02	Bull Edger			
Site 04	Edger	106	1.12	
Site 05	Edger	91	1.21	
Site 05	Edger	96	1.19	
Site 06	Bull Edger(/Re-Saw	94.0-97	1.45	
Site 07	Bull Edger	98.6	0.386	
Site 08	Bull Edger	95	0.721	
Site 08	Edgers	97	0.615	
Site 09	Edger	98	0.207	
Site 11	Edger	93.0-99.8	0.200-5.60	
Site 12	Edger #1	97.9	0.864	
Site 12	Edger #2	100.9	1.01	
Site 13	Bull/Board Edger	98.6	0.759	
Site 17	Edger/Chipper Cab(1)	76.0-79.0	0.028-0.044	
Site 17	Edger/Chipper Cab	93.0-95.0	0.090-0.149	
Site 18	Bull Edger	98	0.748	
Site 21	Edger #1	94	0.061	
Site 21	Edger #2	95	1.318	✓
Site 22	Edger	100.7-106.3	0.392-0.516	

Table 41: Trimmer – Compiled Data of the 22 Sites
 (refer to particular Site ID for Biotest Results)

ID	LOCATION	RESULTS		
		NOISE (dB(A))	DUST (mg/m ³)	BIOTEST Done
Site 01	Trimmer	103.1-105.2	0.630-1.070	
Site 02	Trim Saw Operator Station	93.0-95.0	0.300-0.800	
Site 04	Trimmerman #1	97.7	0.53	
Site 04	Trimmerman #2/Grader	98.3	0.346	
Site 05	Trimmer	92	2.25	
Site 05	Trimmer	97	2.1	
Site 06	Tailer/Trimmer	94.8	1.54	✓
Site 07	Trimmerman #1	96.8	0.326	
Site 07	Trimmerman #2	98.4	0.575	
Site 08	Trimmer	92.5	0.62	
Site 09	Trimmerman #1	98.9	0.319	
Site 09	Trimmerman #2	100.4	0.15	
Site 12	Trimmer, right side of line	100	0.704	
Site 12	Trimmer, left side of line	100	0.647	
Site 13	End Trimming	99.3	0.965	
Site 14	Grader/Trim Saw	104	0.334	
Site 15	Trimmer/Debarker Cab(1)	70	0.051	
Site 20	Trimmer	94	0.100-0.501	
Site 21	Trimmer	99	0.389	
Site 22	Trim Saw	98.1-98.5	0.127-0.779	

Table 42: Chipper – Compiled Data of the 22 Sites
 (refer to particular Site ID for Biotest Results)

ID	LOCATION	RESULTS		
		NOISE (dB(A))	DUST (mg/m ³)	BIOTEST Done
Site 02	Chip and Saw	93.0-98.0	0.252-0.398	
Site 03	Chipper/Hog Room	102	0.511	✓
Site 05	Chipper/Slash Booth	100	2.49	
Site 12	Chipper	103.8	0.567	
Site 13	Chipper	98.5	0.056	
Site 13	Chipper	98.5	0.056	
Site 15	Chip Line	107	0.063-0.495	
Site 15	Chipper Room	107	0.771	
Site 17	Chipper Cab(1)	80.0-82.0	0.128-0.168	
Site 17	Chipper Cab	97.0-105.0	0.498-2.27	
Site 18	Chipper	108	0.289	
Site 20	Chipper Cab	78	0.011-0.046	
Site 20	Chipper, beside Cab	93	0.050-0.109	
Site 21	Chipper	101	0.419	

Table 43: Headrig/Sawyer/Band Saw – Compiled Data of the 22 Sites
 (refer to particular Site ID for Biotest Results)

ID	LOCATION	RESULTS		
		NOISE (dB(A))	DUST (mg/m ³)	BIOTEST Done
Site 01	Sawyer	96.0-103.0	0.670-1.50	
Site 04	Head Rig Cab	80	0.2	
Site 04	Head Rig	100.9	0.312	
Site 07	Sawyer Cab	85	0.3	
Site 07	Sawyer	102	0.249	
Site 08	Sawyer	70	0.053	
Site 09	Sawyer Cab	75	0.053	
Site 10	Bandsaw	95.4-100.00	0.073-0.255	
Site 12	Sawyer Cab	77	0.13	
Site 12	Sawyer	99	0.075	
Site 12	Tail Sawyer, #2 side	97	0.529	
Site 12	Tail Sawyer, #1 side	98	0.847	✓
Site 13	Sawyer Cab	92	0.9	
Site 13	Sawyer	102	1.33	
Site 15	Swing Saw Cab	83	0.278	
Site 15	Swing Saw	95	0.642	
Site 17	Band Saw	68	0.025-0.056	
Site 18	Head Saw Operator Booth	75.9	0.099	
Site 20	Canter #1 Cab	70	0.053-0.369	
Site 20	Canter, beside Cab	93	0.147-0.235	
Site 20	Canter #2	98.5	0.367-0.641	
Site 21	Band Saw	94	0.033	
Site 22	Head Cutter	81.8-99.1	0.110-0.170	
Site 22	Ripper	84.8-98.0	0.090-0.122	
Site 22	Ripsaw Area	94.5-98.0	0.155-0.169	

Table 44: Resaw – Compiled Data of the 22 Sites
(refer to particular Site ID for Biotest Results)

ID	LOCATION	RESULTS		
		NOISE (dB(A))	DUST (mg/m ³)	BIOTEST Done
Site 04	Re-Saw	103	2.8	✓
Site 09	Re-Saw	100.3	0.394	✓
Site 12	Re-Saw	100	1.3	
Site 12	Re-Saw, Jacking wood	103	0.82	
Site 13	Re-Saw	101	1.25	
Site 13	Re-Saw Tailer	100.9	0.817	✓
Site 14	Re-Saw	104	0.323	
Site 18	Re-Saw Tail/Edger	95	0.18	
Site 21	Resaw	94	0.083	
Site 22	Resaw	102.1-103.3	0.353-0.551	

Table 45: Planer – Compiled Data of the 22 Sites
(refer to particular Site ID for Biotest Results)

ID	LOCATION	RESULTS		
		NOISE (dB(A))	DUST (mg/m ³)	BIOTEST Done
Site 03	Planer	92	0.288	
Site 03	Peeling	95.2	0.277	
Site 03	Peel Conveyor	93	0.31	
Site 10	Planer	92.4-97.9	0.061-0.212	
Site 17	Planer Mill, Tilt Hoist	96.0-98.0	0.034-0.980	
Site 17	Planer Mill, Planer Feeder(1)	104	0.170-0.994	
Site 17	Planer Mill, Grader(1)	95	0.138-0.607	
Site 17	Planer Mill, Lift/Skid/Slip Area	96.0-98.0	0.455-1.14	
Site 17	Planer Mill, Stacker(1)	98.0-103.0	0.088-0.479	
Site 17	Planer Mill, Strapping/Packaging	80.0-88.0	0.085-0.222	
Site 19	Planer	107	0.585	✓
Site 20	Planer Mill Infeed	98	0.061-0.495	
Site 20	Planer Mill, Hand Piling	95.6	0.128-0.386	
Site 20	Planer Mill, Dunnage Cutter	95.6	0.101-0.229	
Site 20	Planer Mill, Planer	97	0.108-0.652	
Site 20	Planer Mill, Stud Stacker	97	0.116-0.309	
Site 20	Planer Mill, Economy Stacker	93	0.051-0.231	
Site 20	Planer Mill, Strapper	88.4	0.005	
Site 20	Planer Mill, Planer Room	117	0.007-0.312	
Site 22	Planer #1	101.4-107.2	0.122-0.227	
Site 22	Planer #2	102.8-107.2	0.208-0.227	

Table 46: Slasher – Compiled Data of the 22 Sites
(refer to particular Site ID for Biotest Results)

ID	LOCATION	RESULTS		
		NOISE (dB(A))	DUST (mg/m ³)	BIOTEST Done
Site 02	Slasher Cab	65.5	0.014-0.224	
Site 02	Slasher	76.0-80.0	0.032	
Site 17	Slasher Cab(1)	69.0-71.0	0.009-0.079	
Site 17	Slasher	97	0.004	
Site 20	Slasher Cab	79	0.04-0.346	
Site 20	Slasher, beside Cab	93.0-101.0	0.276-0.560	
Site 20	Slasher Cab	79	0.04-0.346	
Site 20	Slasher, beside Cab	93.0-101.0	0.276-0.560	

Table 47: Veneer Plant – Compiled Data of the 22 Sites
(refer to particular Site ID for Biotest Results)

ID	LOCATION	RESULTS		
		NOISE (dB(A))	DUST (mg/m ³)	BIOTEST Done
Site 03	Peeling	95.2	0.277	
Site 03	Peel Conveyor	93	0.31	
Site 03	Defect Station	89	0.273	
Site 03	Marking Station	88	0.153	
Site 03	Lunchroom	65	0.089	✓
Site 03	Crate Room	100	0.027	
Site 03	Gluing	82	0.164	
Site 03	Splicer #1	84.1	0.247	
Site 03	Splicer Booth	80.4	0.214	
Site 03	Outdoors	69.8	0.161	
Site 03	Lathe Operator Station(1)	98.8	0.197	
Site 10	Peeler	91.3-96.9	0.073	
Site 10	Peeler	92.8-98.0	0.077-0.205	
Site 10	Clipper #1	90.2-94.2	0.061-0.105	
Site 10	Clipper #2	90.8-93.7	0.073-0.088	
Site 10	Slicer	94.8	0.54	
Site 10	Slicer, Operator's station	95.1	0.155	
Site 10	Dryer Feed	92.0-93.6	0.093-0.132	
Site 10	Dryer Outfeed	91.6-92.7	0.077-0.105	
Site 10	Vat Loading Area	91.7-93.4	0.039-0.063	

Table 48: Grading – Compiled Data of the 22 Sites
(refer to particular Site ID for Biotest Results)

ID	LOCATION	RESULTS		
		NOISE (dB(A))	DUST (mg/m ³)	BIOTEST Done
Site 01	Grader	96.3-101.0	0.030-1.150	
Site 05	Trimmer/Grader	96	0.306	
Site 11	Graders	99.0-107.0	0.8	
Site 15	Grading Booth	80	0.282	
Site 15	Grading Booth	75	0.35	
Site 16	Grading Line	84.0-92.0	0.073	✓
Site 22	Grading Line	92.8-97.9	0.097-0.112	

Table 49: Boardway/Green Chain– Compiled Data of the 22 Sites
(refer to particular Site ID for Biotest Results)

ID	LOCATION	RESULTS		
		NOISE (dB(A))	DUST (mg/m ³)	BIOTEST Done
Site 01	Piler	77.9-96.3	0.200-0.300	
Site 04	Boardway	67.7	0.055	
Site 07	Boardway	82	0.107	
Site 09	Boardway	76.5	0.066	
Site 12	Boardway			
Site 13	Boardway	86.8	0.415	
Site 20	Bin Sorter	98	0.055-0.133	
Site 20	Stacker	95	0.077-0.220	
Site 21	Boardway/Stacking	86	0.339	
Site 22	Piler	85.2-99.7	0.126-0.167	

Table 50: Filing Room– Compiled Data of the 22 Sites
(refer to particular Site ID for Biotest Results)

ID	LOCATION	RESULTS		
		NOISE (dB(A))	DUST (mg/m ³)	BIOTEST Done
Site 04	Filing Room	77.9	0.034	
Site 05	Filing Room	99	2	
Site 05	Filing Room	79	1.28	
Site 11	Filer Room	76.6-92.5	0.2	
Site 15	Filing Room	93	0.3	
Site 22	Filing Room	85.0-96.7	0.137-0.923	
Site 22	Filer	83.4-105.2	0.817-0.837	

**Table 51(a): Summary Table of Similar Locations of the 22 Sites
(Values sorted based on Noise Median Low to High)**

Location	N	Noise (dB(A))			Dust(mg/m ³)		
		Median	Max	Min	Mean	Max	Min
Meeting Room	15	61.3	75.1	55.8	0.089	0.360	0.000
Outdoors	13	68.1	77.7	58.0	0.024	0.105	0.002
Log Yard	6	69.5	82.0	66.0	0.029	0.040	0.010
Slasher	8	79.0	97.0	65.5	0.178	0.418	0.004
Broadway/GreenChain	9	86.8	98.0	67.7	0.180	0.415	0.055
Bailer	1	87.5			0.427		
Debarker	31	89.0	101.0	69.0	0.521	3.430	0.005
Filing Room	7	90.9	99.0	77.9	0.739	2.000	0.034
Steam Room	3	92.0	97.0	75.0	0.049	0.096	0.026
Veneer Plant	20	92.4	100.0	65.0	0.172	0.540	0.027
Headrig/Sawyer/Band Saw	24	93.5	102.0	68.0	0.345	1.330	0.033
Grading	7	95.4	95.4	67.7	0.129	0.800	0.073
Edger	19	97.0	106.0	77.5	0.804	2.900	0.036
Planer	21	97.0	117.0	84.0	0.299	0.798	0.005
Trimmer	20	98.3	104.2	70.0	0.700	2.250	0.051
Chipper	14	100.5	103.8	78.0	0.529	2.490	0.029
Resaw	10	101.0	104.0	94.0	0.842	2.800	0.083

**Table 51(b): Summary Table of Similar Locations of the 22 Sites
(Values sorted based on Dust Mean Low to High)**

Location	N	Noise (dB(A))			Dust(mg/m ³)		
		Median	Max	Min	Mean	Max	Min
Outdoors	13	68.1	77.7	58.0	0.024	0.105	0.002
Log Yard	6	69.5	82.0	66.0	0.029	0.040	0.010
Steam Room	3	92.0	97.0	75.0	0.049	0.096	0.026
Meeting Room	15	61.3	75.1	55.8	0.089	0.360	0.000
Grading	7	95.4	95.4	67.7	0.129	0.800	0.073
Veneer Plant	20	92.4	100.0	65.0	0.172	0.540	0.027
Slasher	8	79.0	97.0	65.5	0.178	0.418	0.004
Broadway/GreenChain	9	86.8	98.0	67.7	0.180	0.415	0.055
Planer	21	97.0	117.0	84.0	0.299	0.798	0.005
Headrig/Sawyer/Band Saw	24	93.5	102.0	68.0	0.345	1.330	0.033
Bailer	1	87.5			0.427		
Debarker	31	89.0	101.0	69.0	0.521	3.430	0.005
Chipper	14	100.5	103.8	78.0	0.529	2.490	0.029
Trimmer	20	98.3	104.2	70.0	0.700	2.250	0.051
Filing Room	7	90.9	99.0	77.9	0.739	2.000	0.034
Edger	19	97.0	106.0	77.5	0.804	2.900	0.036
Resaw	10	101.0	104.0	94.0	0.842	2.800	0.083

8. DISCUSSION:

35 firms in the Ontario sawmill and plywood/veneer wood processing industry under WSIB rate groups 033 and 036 responded to the survey. Another 17 declined participating in the survey. Although the number of questionnaires mailed out to industry were dependent upon declared firm size (full-time equivalents), and a large proportion of the mailed out surveys (approximately 45%) were sent to smaller firms making up 80% of the industry, these smaller firms by-and-large did not participate in the survey. 68% of the registered firms in Ontario employ less than 5 workers (according to 2005 OFSWA statistics). Our response rate for the smaller firms in both 1-5 workers and 6-19 workers firms was around 10% (8 in total). Considering that there are over 340 firms in Ontario defined as small business these numbers make interpreting the data difficult. Therefore, we cannot characterize the small business sawmill plywood/veneer industry with confidence given the low numbers. In contrast, approximately 33% of the larger firms responded to the survey allowing us to draw better conclusions about the bigger players in the industry.

There are three possible reasons for this disparity in response rate. This may be due to the greater tendency of larger firms to be organized and to recognize health and safety issues with interest due to legislative requirements or due to the availability of resources (financial and human). Another possible reason and the more likely one for the greater number of respondents from larger firms is the heightened level of awareness and interest in health and safety amongst larger firms. The larger firms are more likely to employ a safety professional or a manager with knowledge of health and safety issues and legal requirements. They are also easier targets for corporate scrutiny and provincial enforcement. This greater interest may have resulted in a better response from larger firms. Finally, many of the smallest sawmill industry employers operate seasonally or are owner/operator home-based businesses. It is possible that some of the firms that received the questionnaires were unable to respond because they were closed for the season. Smaller business owners may not grasp health and safety concepts easily or recognize that they are a business component. Under the Occupational Health and Safety Act of Ontario, firms with 5 or fewer workers are exempted from mandatory health and safety representative or health and safety committee requirements. Further, registration with the Workplace Safety and Insurance Board is often treated as an optional business expense rather than a mandatory business requirement.

The authors recognize that a more thorough follow-up on survey non-respondents would have been beneficial but owing to the limited scope of this study and the financial resources which were directed primarily towards field surveys, phone surveys were not undertaken. It is possible that given the opportunity to explain the purpose of the study over the phone, a greater proportion of small business owners could have completed the surveys and provided a better understanding of the industry as a whole. Considering that the respondents were disproportionately from larger firms within the industry, we consider that the questionnaire results are representative of the larger firms. It should also be noted that this questionnaire was not based on a previous design or pretested for validity. Other questionnaires have been described in the literature [Liljelind et al., 2001; Varonen and Mattila, 2000]. Varone and Mattila (2000) studied safety climate and safety practices in the Finish wood-processing industry by surveying 1056 workers in 8 plants. They found that safety

climate and management attitudes towards safety contributed positively towards reducing injury rates. Although our survey was geared towards management, we found that hazard self-awareness awareness and knowledge resulted favourably in the reporting of workplace occupational hazard control programs. These programs or their effectiveness were not verified independently. Further we did not study whether occupational health hazard control programs resulted in differences in injuries or occupational disease reporting among the respondents. Future studies of this industry may opt to include measurements or analysis of the relationships between hazard training, control programs and accident/illness rates.

This survey found that the industry on average makes use of an almost even mix between hardwood and softwood species. This contrasts greatly with the BC forestry industry and those in Nordic countries which are dominated by softwood species. We did find however that more firms in the sawmill sector used almost all softwoods, whereas some firms in the plywood/veneer sector used hardwoods exclusively including some exotic woods not native to Ontario. Therefore, in consideration of these characteristics, conclusions drawn from studies from other jurisdictions may not necessarily be relevant, particularly to the plywood/veneer sector.

The industry employs a large proportion of young workers who are by definition, under 25 years of age. These workers make up a disproportionately large number of the workers killed or critically injured in traumatic incidents annually according to the Ontario Ministry of Labour and the WSIB. Many workers are employed as full-time workers in the larger firms. Many firms operate on a multiple shift basis. As previously explained, this is not necessarily representative if the small businesses in the industry which according to OFSWA, operate seasonally.

The number of workers employed as reported in the surveys was different from what was reported by the WSIB industry listing as provided by OFSWA. The numbers used by the WSIB to rate firms in terms of size is based on full-time equivalents. The size of each firm is calculated using a formula that combines total hours of work and number of workers to determine firm size. This number was provided by OFSWA to determine estimated firm size for the purpose of this study. The employment numbers reported by respondents may have been based on the actual numbers of workers employed, not full-time equivalents since this is a number calculated by the WSIB and not the employers. The numbers included may have been for part-time workers, full-time workers, or both.

We recognize that in retrospect, one of the flaws with the questionnaire design on the topic of years of service is that it did not stratify the experience of workers with more than 5 years of experience. By including a further breakdown of workers with 5-10 years of experience, 11-20, and more than 20 years of experience, we could have more accurately determined the nature of senior tenured workers who are more likely to be at risk of occupational diseases with long latency periods. Knowing the number of workers with significant years of experience would enable us to determine cohort size for a study on health effects on workers with long-term exposure to noise, dust and other occupational exposures.

Although reported widely in the literature as an exposure agent within the sawmill industry [Cormier et al., 2000; Dutkiewicz et al., 2001b; Dutkiewicz et al., 2001a; Dutkiewicz et al., 2001c; Oppliger et al., 2005], most firms did not report biological agents as being present in the workplace. Only 3 reported using anti-fungal or bio-control agents. Only one employer reported the use of a designated substance which was arsenic and it is used as a preservative in the pressure-treatment of lumber.

A greater proportion of firms reported having some form of hearing conservation program (80%) as opposed to respiratory protection/medical surveillance (33%). We can only hypothesize as to the reason for this difference. Hearing protection is regulated under the Industrial Regulations 857, whereas respiratory protection is only mandatory under certain designated substance regulations or in the event that ventilation is insufficient at controlling airborne exposures. PPE – especially respiratory protection – is considered a measure of last resort. Sawmills and plywood/veneers are noisy environments. That much is obvious. Plus the health effect of some of the equipment (pain) is instantaneous. The hazard from dust or other airborne contaminants may not be readily understood as requiring protection.

In respect to the occupational health hazards of the industry, 91% recognized at least one exposure factor – wood dust, moulds, chemicals or noise – as being present in their workplace. We see it as a positive response that 66% of firms conducted regular noise testing in their workplace and 50% conducted tests for dust or chemicals. Only 4 firms sampled for moulds. This is seen as positive because it indicates the potential pool of available hygiene data that could be used in a larger cross-sectional study or even a retrospective exposure study of the industry. This type of data was used in a study of Ontario hardrock miners for silica exposure silicosis [Verma et al., 1989].

In respect to hazard controls, questions respecting ventilation, workplace hygiene and personal protective equipment were addressed. Most firms use a mix of local, general and natural exhaust to control the workplace environment. What is interesting though is that the firms (17) that did not conduct any workplace monitoring for any occupational health hazards were more likely to rely upon natural ventilation only as opposed to mechanical ventilation (general or local). Firms that used local exhaust ventilation systems usually specified that they had a mix of fixed hood, mobile hood or bag and hose systems. It is possible that this observation of ventilation was the direct result of air sampling results from hygiene monitoring that heightened awareness towards the requirements for ventilation systems.

The observation of physical hygiene procedures indicates that a variety of techniques from vacuuming to wet sweeping are used to control settled dust and debris in the workplace environments. Proportionately more employers made use of compressed air (20) or dry sweeping methods (30) for workplace cleanup. We were surprised that only 12 employers used vacuums and only 3 employers reported making use of wet-sweeping clean up methods. Dry sweeping and compressed air produce considerably more airborne dust as compared to vacuuming or wet sweeping and are frowned upon as inferior hygiene practices.

Finally in terms of personal protective equipment, equipment use varied from employer to employer. We were pleased to see that 77% of employers reported some type of respirator

use by their workers. While respirator use may be common, we were not able to ascertain the nature or quality of respiratory protection programs by these employers. A suitable exercise would be to verify the level of compliance with recognized respiratory protection standards as per NIOSH or CSA.

What is especially interesting is that some of the respondents answered “no” to the question whether wood dust, chemicals or noise was a hazard in the workplace. Most still provided respirators, gloves, skin protection or hearing protection to workers.

The odds ratio of employers who perceive any respiratory hazards using ventilation versus employers who do not perceive respiratory hazards using ventilation is 15. The odds ratio of employers who perceive any respiratory hazards using any type of respirator versus employers who do not perceive respiratory hazards using respirators is 19. Finally the odds ratio of employers who perceive any chemical or biologic hazards using hand/skin protection versus employers who do not chemical/biologic hazards using skin protection is 8. This shows that hazard recognition is of utmost importance and has a direct impact on whether engineering controls or personal protective equipment will be required or provided by a employer. The lower odds ratio for skin/hand protection may be due in part to the safety aspect related to hand protection, focus on isolation safety (such as machine guarding) and the ease of recognizing the physical hand safety hazards as opposed to the not-so-identifiable occupational health hazards related to skin protection. Although not possible to calculate, the results for hearing protection show that its use is not dependent upon whether noise is recognized as a hazard. This may be due to a combination of enforcement and widespread industry practice. The hazards of loud noise are readily felt and are most likely treated with the same degree of attention as physical safety hazards.

The results comparing hazard perceptions between health and safety representatives, management health and safety committee representatives and worker health and safety committee representatives were quite interesting as shown in Table 9. Worker JHSC reps consistently perceived occupational exposures to be worse than management members. This would not be surprising though, considering the expected polarity in opinions on the workplace environment between worker representatives and management representatives.

This may be due in part to heightened perceptions of risk severity between labour and management and polarization of safety views and risk assessment. It may also be due to differing personal experiences between labour and management. It is most interesting that health and safety representatives, who are required for firms employing 6-19 workers, consistently rated hazards to be far lower in risk than either worker or management members of the health and safety committees. This discrepancy may be due in part to the certification requirement for members of health and safety committees and the heightened knowledge and hazards awareness which comes with certification training. If true, this would indicate the potential need for some form of formalized training for health and safety representatives who currently are not required to participate in formal certification training.

When asked to rank health and safety compared to other workplace concerns, worker representatives on health and safety committees rated occupational health higher than

management reps or Health and Safety reps in smaller firms. However, all of them rate occupational health as important to very important.

It has been reported in the literature that safety climate and management attitudes towards safety and wellness have resulted in reduction in incidents and improved workplace attitudes towards safety [Garcia et al., 2004; Rasmussen et al., 2006; Varonen and Mattila, 2000]. A recent meta-analysis on safety culture and safety performance found a positive correlation between employee safety compliance and participation [Clarke, 2006]. Management and leadership attitudes towards safety can have a positive or negative effect towards health and/or safety [Clarke and Ward, 2006]. A positive safety climate can result in better employee participation and safety compliance. It would be helpful in the future to study the correlation between management attitudes towards occupational health, health program compliance and occupational disease rates in the industry. When questioned about hazard investigations, more health and safety representatives investigated no hazards at all than either the worker or management health and safety committee members. Once again, this may be due to the smaller workforce, less financial resources or time, or lower level of hazard education.

The impressions of the questionnaire survey were generally confirmed in the field visit walk-thru surveys conducted at 22 sites of 17 different companies and from additional information obtained on chemical exposures. No inhalable dust and only limited total dust data were available from any of the companies visited. This would indicate the need of a more detailed wood dust exposure survey where side by side total dust and inhalable dust are measured simultaneous over the whole shift to get full-shift exposure. This needs to be done not only for the traditional jobs but also for processing operations such as carpentry, pattern making etc.

Wood type particle size specific data would also be of interest to know. Effects on particle size if the saws were not properly maintained, whether wood is planed, sanded etc. needs to be assessed.

During the walk-thru survey, it was observed that there does not appear to be documentation of maintenance regarding ventilation systems. Routine testing of the effectiveness of ventilation systems would be effective in controlling dust exposure. Slip, trips and falls may result from wood dust on floors (i.e. poor house keeping) of buildings in production areas or due to inadequate lighting. Noise and vibration were prevalent throughout most of the plants visited except in the operator's cab which can be seen in the tables of this report. Some of the cabs observed during walk-thru were in need of repair and consequently they were noisier than others. Planing and sanding areas are noisy. The possibility of lacerations from handling wood or from airborne splinters was noted during visits at debarker and most other chipping/sawing operations can produce airborne splinters. Equipment guarding can be improved which also would aid in dust containment at wood equipment interface.

No species specific wood dust data was available at the plants visited. The degree of differences between dust production of hardwood and softwood is not known. It is realised that differentiation between wood related exposures is difficult, given mixture of wood types

used. Some mills only use softwood and some only hardwood. They may serve for exclusive softwood and/or exclusive hardwood exposures.

The issue of potential dermatitis did not seem to be very important, which may be more of a concern in construction and other wood working professions, where wood is routinely handled and cut in non-ventilated areas. Exposure to biological agents is of concern. Bacteria/mould sampling and analysis of log pond, debarker (due to log deck wood being wet and the cellulose substrate i.e. bark) and chipper (i.e. hog room) could be undertaken. However, where operators are inside a cab, the exposure will only occur when the operator is outside of the cab. Volatile organic compounds (VOCs) may be thermally evolved (i.e. terpenes, aldehydes, some pesticide if temperature is high enough) in kiln areas. Other areas that may produce high temperature interfaces are planing, sanding and chipping, possibly leading to off gassing. Filling room employees should be monitored for metal fumes, including cobalt and chromium because of welding repair of the band saw teeth. In the veneer plants, formaldehyde may be released during veneer/plywood hot pressing when using either urea-formaldehyde or phenol-formaldehyde resin. It can also occur during glue mixing. There would be a concern of repetitive stress/ergonomics concern due to repeated manual manipulation of boards.

During the walk-thru survey as stated earlier, only wood dust, noise and limited biological agents were measured. Noise levels measure ranged from 55 to 117 dB(A) (see Table 51). Exposure to noise at many locations are above the current exposure limit of 90 dB(A) and many more locations will be above the proposed Ontario regulation of 85 dB(A). An industry wide noise survey could also be beneficial. Biological exposure (mould and fungi) data are given for individual plants and it generally shows certain areas/operations as being high. Due to cost and other limitations, a detailed assessment of biological agents was not possible but the results (see Tables 13-20, 23, 24, 26-32 denoted as (b)) show where a detailed study may be worth while. The result of dust measurements conducted by DustTrak gives only instantaneous readings and not traditional time-weighted 7 to 8 hours dust exposure. They approximate the dust fraction which will be measured by total dust convention. The current regulation in Ontario is by total dust. The dust exposure on average can be seen in Table 51 and they range from 0.002 mg/m³ to 3.430 mg/m³ with mean values ranging from 0.09 to 0.84 mg/m³ (see Table 50). It would appear the total dust levels on average may be below 5 mg/m³ (the current Ontario standard). The earlier unpublished Ontario study had found total exposure ranging from 0.1 to 6.1mg/m³, where long term samples were taken [Holliday et al., 1985]. The trend of relatively lower wood dust exposure in sawmill and primary industry compared to other wood dust exposure sectors have also been reported recently in a study of inhalable wood dust exposure in the 25 members of the European Union [Kauppinen et al., 2006]. A comprehensive exposure assessment of airborne wood dust exposure needs to be conducted in the Ontario sawmill and veneer plants. Such an assessment would require obtaining a statistically significant number of both personal and area samples (including long term samples i.e. full-shift samples) for both total and inhalable dust. It is important to include assessment of inhalable dust, since wood dust occupational exposure limits are being promulgated in many jurisdictions as inhalable dust.

9. CONCLUSIONS:

Based on the results of the questionnaire survey, we were able to characterize, with some degree of confidence the industry characteristics and attitudes and behaviours towards occupational health and hygiene in firms employing 20 or more workers. Due to the low response rate in firms with less than 20 workers, we cannot make any conclusions regarding occupational health or hygiene in this large proportion of the Ontario Sawmill and plywood/veneer industry. The industry uses a 55/45 mix of softwood vs. hardwood species with proportionately more hardwood use in the plywood/veneer industry. The larger industry players employ a large number of young workers. Occupational health hazards including noise, dust and mould are recognized as workplace hazards by most employers responding to the surveys. Mechanical ventilation is more likely to be used by firms that have performed air monitoring in the past. The industry reports having some industrial hygiene data which could serve as the foundation for a retrospective hygiene exposure study of the industry. Joint health and safety committee worker representatives perceive occupational health hazards to be worse than management representatives. Health and safety representatives in the small business sector have the lowest opinion towards occupational health hazards or control issues. Better occupational health education programs should be directed towards the small business elements of the industry.

Based on the results of questionnaire survey and walk-thru survey it appears that health records/data is not uniformly available throughout the industry. In our opinion, therefore, an industry wide health study (i.e. epidemiological study of dose-response for wood dust) will not be feasible. It is possible, that such a epidemiological health study can be done if limited to the large companies where both health records and exposure data of sufficient quantity and quality may be available.

Based on results of the direct reading dust measuring device, it would appear that wood dust exposures are most likely to be below the current exposure limit of 5 mg/m^3 as total dust. This, however, needs to be confirmed by long-term sampling. A comprehensive industry wide wood dust exposure study should be carried out. This should be done using long term sampling techniques and by measuring both total dust and inhalable dust. Statistically significant numbers of both personal and area samples for total and inhalable dusts would be very useful.

Noise levels in the industry at many operations will exceed the proposed Ontario standard of 85 dB(A) for 8 hours, so an industry wide noise survey would be useful. Biological Agents may also be assessed in greater detail than was possible in this study.

10. RECOMMENDATION FOR FUTURE WORK:

A comprehensive industry wide wood dust exposure study should be carried out. This should be done using a long term sampling technique and by measuring both personal and area samples for total and inhalable dust. A statistically significant number of both personal and area samples needs to be taken in such a study. An industry wide noise survey would be useful and should be considered. Exposure to biological agents is of some concern and it would be prudent to conduct sampling at a limited number of plants in a more comprehensive manner assessment for bacteria /fungi at log pond, debarker and chipper.

11. PLANS FOR DISSEMINATION OF RESEARCH FINDINGS:

- 1) The research finding will be presented to the sawmill industry and its stakeholders by the research team and OFSWA at various venues such as at Joint Health and Safety Committee meetings, Regional meetings, etc.
- 2) After the WSIB-RAC has approved the final report, copies will be distributed to all participating companies. Since the company and sites in the report are only identified by as sites, each company will be supplied with its code for their company and sites.
- 3) The research finding will be submitted for publication in scientific and professional journals.

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