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Confidential

Wood Usage in Non-Residential and Multifamily Construction in British Columbia – 2009 Benchmark
Final Report

by

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Executive Summary

This study reports 2009 market share for wood in British Columbia in non-residential and multifamily construction. Actual and potential wood usage is quantified by building type and by BC region, with an emphasis on structural applications. The intention is to provide benchmark statistics against which to measure the effect of the Wood First Act and other market growth initiatives, and the change in the BC Building Code allowing taller wood-frame multifamily buildings. Quantitative data is developed using purchased statistics and applying usage factors from previous studies. The economic downturn in 2009 likely impacts this baseline, so caution is advised. Telephone interviews with a sample of project teams helped fine-tune the quantitative estimates and provided qualitative data on drivers and barriers to wood use.

Key findings:

Share

- Overall, wood has a 12% share of floor area in the 1-4 storey non-residential segment, with almost a million square feet of floor area. This figure compares to a 33% share within the segment where wood is allowed by code. Wood share is lower in the public sector,
- In the 1-6 storey *Residential* segment wood has a 75% share of floor area. Growth in this segment might come from approaches such as post and beam and/or CLT.
- Wood has 26% area share in *Institutional*, 10% in *Commercial*, and nearly 0% in *Industrial*,
- The opportunity for growth (defined as where wood could be used within the existing code) is estimated at an additional 2.5 million square feet (80% increase in floor area, 11% Public),
- Fifty-seven percent of the total floor area is concentrated in the Vancouver area,
- Total floor area of construction was estimated at 13.6 million square feet -equivalent to 3.6 billion CAD- with 276 projects in total (new construction + additions to existing buildings). New construction accounted for 82% of the gross floor area. In terms of categories, *Commercial* accounted for 27% of the area, *Institutional* for 31%, *Residential* for 28%, and *Industrial* for 14%
- Mixed (hybrid) projects (e.g., concrete plus wood) make up 10% of all new buildings; however in the *Residential* category they represent roughly a third of all projects.

Wood Use

- 19,000 MBF (19 million board feet) of lumber and Engineered Wood Products (EWP) (1.39 BF/sq.ft.) and 17,000 MSF of structural panels (1.24 sq.ft./ sq.ft.),
- 104,000 metric tons of total combined CO_2 effect, equivalent to 1 year of emissions from 536,000 cars,
- The growth opportunity from project conversion from non-combustible to wood is equivalent to 8,000 MBF of lumber and EWPs and 6,000 MSF of panels. Heavy timber roofs could add 4,600 MBF and 2,200 MSF of panels. Another potential market is roofs in industrial buildings,
- Hindering perceptions: Code, fire, higher maintenance cost, durability, procurement, and design.

Baseline for 'Wood First' tracking (Public buildings)

- Wood construction: 44,000 m^2 (n=37) (10 Commercial, 22 Institutional, 5 Residential),
- $2.2 billion in construction value,
- Wood share: 11% (Area), 7% (Value), 36% (Buildings number). By contrast, the private sector has 31%, 34% and 44% share in the same categories,
- 3,000 MBF of lumber and EWP's (0.71 BF/sq.ft.); 4,200 MSF of structural panels (0.99 sq.ft./ sq.ft.),
- 16,000 metric tons of total combined CO_2 effect, equivalent to 1 year of emissions from 3,000 cars,

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Introduction

The first part of this study took a preliminary look at wood share in non-residential construction in BC in 2009. The second part of this study looked further into wood share and wood usage, quantifying potential use by building category and type. Telephone surveys were used to acquire qualitative information on wood usage in BC, its drivers and hindering factors. Usage of wood products was estimated using usage factors from a previous study performed for 1-4 storey non-residential US buildings[1]. These [structural] factors include a waste factor (5-10%). Material used in concrete forming is not included.

Additionally, this study incorporates the calculation of some environmental footprint indicators, such as carbon stored and carbon emissions avoided. Wood use is also converted into some indicators such as time to regenerate that volume in BC forests and consumption per BC inhabitant.

Some changes were introduced in order to make the results compatible with previous work from other organizations. For instance the list of building types was expanded and the original five geographic zones were consolidated in four zones.

Further, the results are broken down into private and public projects allowing the linkage to other initiatives such as tracking the effect of the Wood First Act. In that regard, this study's findings may constitute the baseline for future tracking purposes. Some indicators are proposed to that effect.

Background

Non-residential construction represents one of the greatest growth opportunities for wood products in North America. With wood already the strongly dominant structural material in the residential sector, non-residential construction is the only domestic target for any significant increase in structural wood consumption.

In BC, as in most jurisdictions, the market share of wood in non-residential buildings falls well short of its potential. Non-residential buildings are all those not intended as homes: schools, hospitals, retail, offices, churches, airports, stadia, prisons and so forth. This construction sector is sometimes called ICI – Institutional, Commercial, Industrial.

The most recent data for North America as a whole indicates that, while the non-residential construction sector is often nearly as large as the residential sector in terms of construction value, the volume of lumber and structural panels used in non-residential construction is less than 10% of the volume used in new residential construction (RISI 2006, McKeever and Adair 1998, McKeever *et al.* 2006, McKeever 2008). This indicates a major potential market for structural wood products.

Until recently, the North American wood sector has typically had its attention fully occupied by intense residential demand; this may be the cause of a historical lack of interest on the part of the wood industry in other markets. However, diversification into the non-residential market provides a buffer for downturns in housing starts and for market share loss to competing materials in housing, a topic of rising concern in some North American regions. While economists remain unsure how long and steep the drop in housing will ultimately be, the Canadian wood products sector is severely feeling a reduction in demand. One way

[1] McKeever, D., C. Adair and J. O'Connor. 2006. Wood products used in the construction of low-rise non-residential buildings in the United States, 2003. Wood Products Council. (Updated in 2008)

to maintain a strong demand for wood in a soft housing market is to develop increased wood usage in non-residential building construction.

Various regulations restrict the use of structural wood in non-residential applications due to perceived life safety risks from wood's combustibility. Among other factors, wood application is limited as a function of: 1) the intended usage of the building; 2) how accessible the building is for firefighting; 3) building height; 4) building area or footprint; and 5) whether or not the building is equipped with sprinklers. However, while wood may not be an appropriate structural building material for all non-residential buildings in North America, code-related issues have been estimated to still allow wood access to approximately 64% of U.S. non-residential construction by value (McKeever *et al.* 2006). Given that wood currently has captured an average of only 8% of all U.S. non-residential construction value; this represents tremendous room for growth (McKeever *et al.* 2006). Note that this report makes use of some data and statistics generated for the United States, which are likely fully applicable to the construction market in BC.

As described in previous market studies (Gaston *et al.* 2001, Kozak and Cohen 1996, O'Connor *et al.* 2004), determining the exact decision path for structural material selections is difficult. In most cases, materials are selected based on precedent. Wood is typically not a common material in non-residential construction (hence, not a precedent), and cost and risk scenarios for the construction sector provide strong disincentives for change of any nature. In addition, various pragmatic concerns of each individual participant on the design team (the architect, the structural engineer, the builder and the project owner) all tend to currently favour steel and concrete over wood.

For example, while the building code allows the structural use of wood in many non-residential buildings, the architect is typically faced with additional or more complicated design requirements (e.g., with respect to life safety in the event of a fire) when using wood. In the case of engineers, working with wood may require more design time without a corresponding increase in fee; in addition, the engineer may not have confidence in the skill level of the wood trades to execute the design with the required level of precision. Builders and owners are most concerned with minimizing risk, which means fluctuating prices of wood, increased insurance costs for wood construction, and typically lower market values of wood buildings are some of the reasons they cite for preferring steel and concrete.

Previous research studies on opportunities for wood market growth in non-residential construction in the U.S. and Canada suggest a promising potential market but also highlight some substantial barriers that include code, technical, product, educational and image issues (Gaston *et al.* 2001, Kozak and Cohen 1996, O'Connor *et al.* 2003, 2004). Previous work in BC has shown these barriers to be somewhat less serious than in other North American regions, suggesting that growth potential in BC is particularly attainable (CV Marketing Research 2004a,b).

1 Objectives

Overall, this project has the following objectives:

- Benchmark 2009 wood use in non-residential and mid-rise construction in the province of British Columbia by percent of market capture, and estimate wood consumption volumes.
- Determine wood market potential as allowed under the BC Building Code, and calculate maximum incremental wood consumption if the market were fully captured by wood.
- Identify barriers and opportunities for greater wood use in non-residential construction.

2 Methodology

2.1 Data Sources and Adjustments

We acquired construction statistics for the province of British Columbia from two data providers: Reed Construction Canada and McGraw-Hill Construction. The datasets included all 1-10 storey non-residential and multi-family residential projects (apartments and condominiums) reported in 2009, including all stages, from planning to occupancy. Quantitative data was developed using this purchased construction statistics and applying wood usage factors from previous studies. Telephone interviews with a sample of project teams helped fine-tune the quantitative estimates and additionally provided qualitative data on drivers and barriers to wood use.

The year 2009 was selected due to the significance of the changes introduced to the building code and the promulgation of the wood first act, aimed at facilitating a culture of wood. These two important milestones make 2009 an appropriate choice to be used as a baseline for wood uptake tracking purposes. It should be noted that some peculiarities of this year may have introduced some anomalies in the results. For instance, prices for wood products were at all-time lows which might have resulted in a boost for demand. However construction levels plunged from previous years before creating an opposite effect. Several differences can be found for nonresidential construction in BC in 2009 when compared to the construction levels reported in the study by O'Connor (2008)[2]. After adjusting the 2009 dataset to include only nonresidential 1-4 storey buildings (similar to the 2006 dataset) we get a $2.3 billion construction starts value versus $3 billion permits value in 2006. Similarly, the 2009 dataset exhibits 248 starts versus 442 permits (194 selected) in 2006. In terms of floor area 2009 seems to have half the area of 2006 (8.3 million sq.ft. vs. 16.8). This difference in floor areas calls for caution when drawing conclusions regarding growth in construction areas and demand for wood products.

Several changes in methodology were introduced with respect to the 2006 study. In this case we relied on commercially available datasets of actual starts rather than a sample of building of permits. Material usage data for 2009 was provided in the purchased datasets, whereas the 2006 method gathered material usage data through phone interviews. While both methods have potential for data quality problems, the purchased data may be more accurate as it is presumably gathered from the design team in a timely manner with respect to the team's work on that project. In contrast, the 2006 phone survey approach was querying design teams after they had completed work on these projects and had moved on to new

[2] O'Connor, J. 2008. BC Non-residential Market Assessment 2006.

projects; a memory problem or lack of time to open an old file are inhibiting factors in this form of data collection.

The 2006 study operationalized a wood building as one having both roof and exterior walls built in wood whereas this study only referenced the material used for the exterior walls as the defining criterion. This was due to lack of reliability and unbalance of the information regarding roof material[3]. The 2009 dataset also incorporates all building heights up to 10 stories and multifamily buildings.

In reporting of market share by building type, the 2006 and 2009 building type categories are substantially different and therefore results segmented by building type cannot be directly compared across those two studies.[4] The 2006 dataset was segmented according to BC building code definitions, while the 2009 dataset uses the ICI breakdown (institutional, commercial, industrial), which is typically how published construction statistics are delivered. In that approach, the determination of which buildings fall into which ICI category is significantly driven by building ownership and not just by building usage (as in the building code breakdowns). For example, in the 2006 dataset, all office buildings are reported as a group; in the 2009 data, government offices are reported under Institutional and private offices are reported under Commercial.

In order to get a better assessment of actual construction we selected those projects at the start/construction or completed stages. The selection included new projects as well as additions. Townhouses were not included.

After cross validation and screening, a unified list was put together and used as base for the analysis[5]. Some projects may have been missed by the data providers so the actual numbers are likely to be higher. No adjustment was made to correct sampling issues.

In the case of mixed residential projects with apartment buildings and townhouses in the same project, the floor area of the latter was excluded. The same was done for phased projects to reflect 2009 only. In the case of residential/retail mixed projects the first floor was assumed to be built in concrete and floor areas and shares were calculated accordingly. Table 18 in appendix 1 shows detailed information on mixed use buildings.

Projects were also divided by ownership into public and private. Public buildings are those owned by the city or the province and mostly include institutional buildings.

[3] However 85% of buildings having wood walls also reported a wood roof.

[4] However, this can be accomplished by re-analyzing either of these two data sets according to the parameters of the other set. This is outside the scope of this report.

[5] The final dataset is comprised by the modified Reed dataset plus 11 records from McGraw-Hill.

2.2 Geographic Zones

The Province was subdivided into four zones as follows (Table 1):

Table 1 Geographic Zones

1. Northern	2. Vancouver Area	3. Vancouver Island	4. Southern Interior
Alexis Creek	Vancouver	Alberni-Clayoquot	100 Mile House
Chetwynd	Burnaby	Campbell River	Abbotsford
Dawson Creek	Coquitlam	Central Saanich	Aldergrove
Fort Nelson	Delta	Colwood	Armstrong
Fort Saint John	Langley	Comox	Boston Bar
Fort St John	New Westminster	Courtenay	Chilliwack
Fraser-Fort George	North Vancouver	Cowichan Valley	Clinton
Gingolx	Pitt Meadows	Duncan	Coldstream
Kitimat-Stikine	Port Coquitlam	Esquimalt	Cranbrook
Lower Post	Port Moody	Ladysmith	Enderby
Pemberton	Powell River	Langford	Fernie
Port Simpson	Richmond	Lazo	Hope
Pouce Coupe	Squamish	Long Beach	Kamloops
Prince George	Surrey	Nanaimo	Kelowna
Prince Rupert	West Vancouver	Parksville	Kootenay
Quesnel	Whistler	Port Alberni	Lake Country
Smithers	White Rock	Port Hardy	Lilloet
Squirrel Cove		Qualicum Beach	Maple Ridge
Terrace		Saanich	Merrit
		Sidney	Mission
		Sooke	New Denver
		Tofino	One Hundred Mile House
		Victoria	Penticton
		View Royal	Salmo
			Salmon Arm
			Vernon
			Williams Lake

2.3 Carbon Calculations

As an add-on to this study, we provide a rough estimate of the carbon implications due to the use of wood in the buildings reported here. We used a carbon calculator tool[6] developed by FPInnovations for the BC Forestry Climate Change Working Group, in cooperation with BC FII. This is a spreadsheet tool that takes wood quantity inputs for a building or group of buildings and calculates total carbon stored in the wood materials and total greenhouse gas emissions avoided due to the choice of wood over non-wood materials. We show carbon results in Tables 13 and 14. Total carbon stored in the building is a straight-

[6] Carbon calculator for wood-framed buildings, beta version February 2, 2011, FPInnovations.

forward calculation based on oven-dry mass of the wood (approximately 50% of the dry mass of wood is composed of carbon, which is derived from atmospheric carbon dioxide). Total carbon emissions avoided has much more complexity and uncertainty associated with it. This figure is an estimate of the emissions that would have resulted had all of these wood buildings instead been constructed with non-wood materials. A strong body of literature exists that supports the assumption that a wood building has a smaller embodied carbon footprint than an equivalent non-wood building (Sathre O'Connor 2010). The FPInnovations carbon calculator uses an average "carbon displacement" figure reported in Sathre O'Connor, which the authors derived from a meta-analysis of numerous wood substitution life cycle assessment studies. It is important to view the "avoided carbon" figures with caution, due to a high degree of uncertainty on several factors, including (most prominently) the eventual end-of-life fate of wood materials installed in new construction today.

The carbon calculator tool also estimates the amount of time BC forests will require in order to regrow the total carbon that was removed from the forest in order to manufacture the given mass of wood.

3 Results

3.1 Construction Activity

3.1.1 All Heights (1-10 storeys)

Total floor area in non-residential and multifamily construction in 2009 is estimated at 13.6 million square feet, with a value of 3.8 billion CAD with 276 projects in total (211 New). New construction accounted for 82% of the floor area. In terms of categories, *commercial* construction accounted for 27% of the floor area, *institutional* for 31%, *multifamily* for 28%, and *industrial* for 14%[7]. Tables 2 and 3 summarize the results. Alterations accounted for only 5% of the total value.

Table 2 Construction Level by Project Type

	Floor Area (sq.ft.)	Value ($)	Projects (n)
New	11,174,120	$ 2,376,803,957	211
Additions	2,450,610	$ 1,227,362,020	65
Alterations		$ 186,127,417	82
Grand Total	**13,624,730**	**$ 3,790,293,394**	**358**

Table 3 Construction Level by Project Category (New & Additions)

	Floor Area (sq.ft.)	Value ($)	Projects (n)
Commercial	4,695,461	$ 1,393,876,871	99
Industrial	1,609,080	$ 121,730,000	23
Institutional	4,098,325	$ 1,557,368,613	102
Miscellaneous	24,800	$ 5,000,000	2
Multifamily	3,197,064	$ 526,190,493	50
Grand Total	**13,624,730**	**$ 3,604,165,977**	**276**

[7] Most important types by category: **Institutional**: Educational, Health, Community, Service, **Commercial**: Office, Retail, Lodging, **Industrial**: Manufacturing, Warehouses

In order to gain appreciation of construction levels over time Table 4 shows stats for the last four years.

Table 4 Total Floor Area by Year

Floor Area (000 sq.ft.)	2007	2008	2009	2010
British Columbia	43,000	25,000	14,000	23,000
Canada	168,000	134,000	80,000	128,000

Reed Construction (CanaData Starts, all stories, single and double residential not incl.)

Note that 2009 represented over a 40% plunge from the previous year, with a rebound in 2010, mostly due to multifamily construction. It is noteworthy that institutional construction actually increased by 29% from 2008 to 2009 with the biggest drop in industrial construction (-76%). BC represents roughly 20% of Canada's construction area. For further details see Table 28 in Appendix 1.

Table 5 shows details by building type.

Table 5 Construction Levels by Building Type (New & Additions)

Row Labels	Floor Area (sq.ft.)	Value ($)	Projects (n)
Commercial	**4,695,713**	**$ 1,393,991,186**	**101**
Hotels, motels	665,000	$ 27,000,000	3
Motor vehicle services	172,798	$ 12,275,000	10
Parking buildings	48,160	$ 7,550,000	2
Private office buildings	550,356	$ 62,700,000	20
Public assembly buildings	522,379	$ 910,341,721	10
Recreational buildings	794,057	$ 166,035,265	21
Restaurants	15,521	$ 2,900,000	4
Retail, wholesale services	948,032	$ 100,869,200	23
Shopping centers, plazas	979,411	$ 104,320,000	8
Industrial	**1,609,080**	**$ 121,730,000**	**23**
Agricultural buildings	10,000	$ 700,000	1
Manufacturing plants	622,743	$ 42,780,000	7
Processing plants	4,000	$ 450,000	1
Retail, wholesale services	118,651	$ 11,000,000	1
Warehouse, storage buildings	853,686	$ 66,800,000	13
Institutional	**4,098,073**	**$ 1,557,254,298**	**100**
Defence, law enforcement buildings	63,128	$ 26,043,733	3
Educational buildings	1,422,840	$ 425,046,721	35
Government office buildings	551,923	$ 97,108,361	24
Hospitals	1,318,462	$ 880,728,143	19
Library	7,403	$ 2,928,000	1
Medical / welfare buildings	581,634	$ 90,610,402	8
Passenger terminals	22,216	$ 11,000,000	2
Religious buildings	130,467	$ 23,788,938	8
Miscellaneous	**24,800**	**$ 5,000,000**	**2**
Multifamily	**3,197,064**	**$ 526,190,493**	**50**
Grand Total	**13,624,730**	**$ 3,604,165,977**	**276**

3.1.2 Mid-rise Construction

Changes to the BC Building Code (BCBC) in April 2009 allowed the construction of residential buildings in wood frame up to six stories. Tables 6 and 7 provide an assessment of mid-rise contruction in 2009. We look into share levels below (section 3.4). Five and 6-storey buildings represent only 5% of the number of projects but 12% of the floor area, and 21% of the value, as they tend to be larger and of higher value. Tables 19 to 21 (Appendix 1) show detailed information by number of floors.

a) Mid-rise (5-6)

Table 6 Mid-rise (5-6 Storeys)

Row Labels	Floor Area (sq.ft.)	Value ($)	Projects (n)
Commercial	**63,160**	**$ 11,750,000**	**2**
Parking buildings	28,160	$ 6,450,000	1
Private office buildings	35,000	$ 5,300,000	1
Institutional	**1,104,900**	**$ 661,000,000**	**7**
Educational buildings	167,900	$ 127,000,000	2
Hospitals	812,000	$ 507,000,000	3
Medical / welfare buildings	125,000	$ 27,000,000	2
Miscellaneous	**23,000**	**$ 3,500,000**	**1**
Multifamily	**401,471**	**$ 70,000,000**	**5**
Grand Total	**1,592,531**	**$ 746,250,000**	**15**

b) Mid/High-rise (7-10)

Table 7 Mid/High-rise (7-10 Storeys)

Row Labels	Floor Area (sq.ft.)	Value ($)	Projects (n)
Commercial	**540,000**	**$ 12,000,000**	**1**
Hotels, motels	540,000	$ 12,000,000	1
Institutional	**414,052**	**$ 82,195,450**	**4**
Educational buildings	35,000	$ 7,695,450	1
Hospitals	29,052	$ 28,000,000	1
Medical / welfare buildings	350,000	$ 46,500,000	2
Multifamily	**209,000**	**$ 63,500,000**	**3**
Grand Total	**1,163,052**	**$ 157,695,450**	**8**

3.2 Square Footage by Assembly

Based on parameters from RSMeans[8], total area of assemblies (walls, roof and floors) was calculated (Figure 4, Appendix 1). This is useful when quantifying market opportunities for specific products and or applications, e.g., siding (Table 8).

Table 8 Square Footage by Assembly (New Buildings, All Heights)

Row Labels	Floor Area (sq.ft.)	Ext. Walls (sq.ft.)	Partitions (sq.ft.)	Elev. Floors (sq.ft.)	Roof (sq.ft.)	Projects (n)
Commercial	**2,989,998**	**879,104**	**884,164**	**1,160,299**	**1,495,241**	**75**
Hotels, motels	125,000	38,752	111,045	93,750	23,125	2
Motor vehicle services	167,770	46,337	63,225	48,420	117,350	8
Parking buildings	48,160	22,099	1,852	23,467	24,693	2
Private office buildings	547,056	166,348	225,619	271,189	244,104	18
Public assembly buildings	99,860	54,495	63,071	44,147	55,713	8
Recreational buildings	345,255	126,149	101,667	151,479	182,762	11
Restaurants	14,800	6,554	5,758	-	14,800	3
Retail, wholesale services	775,687	157,627	167,593	124,699	645,869	17
Shopping centers, plazas	866,411	260,743	144,333	403,150	186,824	6
Industrial	**1,574,080**	**361,853**	**305,410**	**446,429**	**1,026,038**	**21**
Agricultural buildings	10,000	9,600	800	-	10,000	1
Manufacturing plants	622,743	116,599	124,490	275,747	245,383	7
Processing plants	4,000	3,795	800	-	4,000	1
Retail, wholesale services	118,651	18,706	47,432	59,325	59,325	1
Warehouse, storage buildings	818,686	213,153	131,888	111,357	707,329	11
Institutional	**3,389,978**	**920,286**	**3,077,283**	**2,112,237**	**1,083,972**	**64**
Defence, law enforcement buildings	63,128	21,538	24,737	24,032	39,096	3
Educational buildings	1,330,572	289,869	905,506	631,144	647,318	26
Government office buildings	116,267	66,354	67,421	38,094	72,173	11
Hospitals	1,211,704	240,704	1,359,330	930,226	172,036	9
Library	7,403	4,336	2,960	-	7,403	1
Medical / welfare buildings	519,634	186,570	631,441	433,214	67,669	6
Passenger terminals	17,216	5,143	11,472	-	17,216	1
Religious buildings	124,054	105,771	74,418	55,527	61,060	7
Miscellaneous	**23,000**	**13,022**	**9,195**	**18,400**	**4,600**	**1**
Multifamily	**3,197,064**	**1,041,329**	**3,166,750**	**2,391,294**	**570,850**	**50**
Grand Total	**11,174,120**	**3,215,594**	**7,442,801**	**6,128,660**	**4,180,701**	**211**

[8] http://www.meanscostworks.com

3.3 Geographic Variation in Construction Activity

Fifty-seven percent of the floor area was built in zone 3 (Vancouver Area) (Table 9). Significant variation in wood share can be observed among zones (Figure 3, Appendix 1).

Table 9 Floor Area by Zone

Row Labels	Floor Area (sq.ft.)	%
Northern	821,810	6%
Southern Interior	2,790,209	20%
Vancouver Area	7,820,985	57%
Vancouver island	2,191,727	16%
Grand Total	**13,624,730**	**100%**

Figure 1 shows total floor areas by city. As expected, most construction is concentrated around Vancouver, with 57% of the floor area.

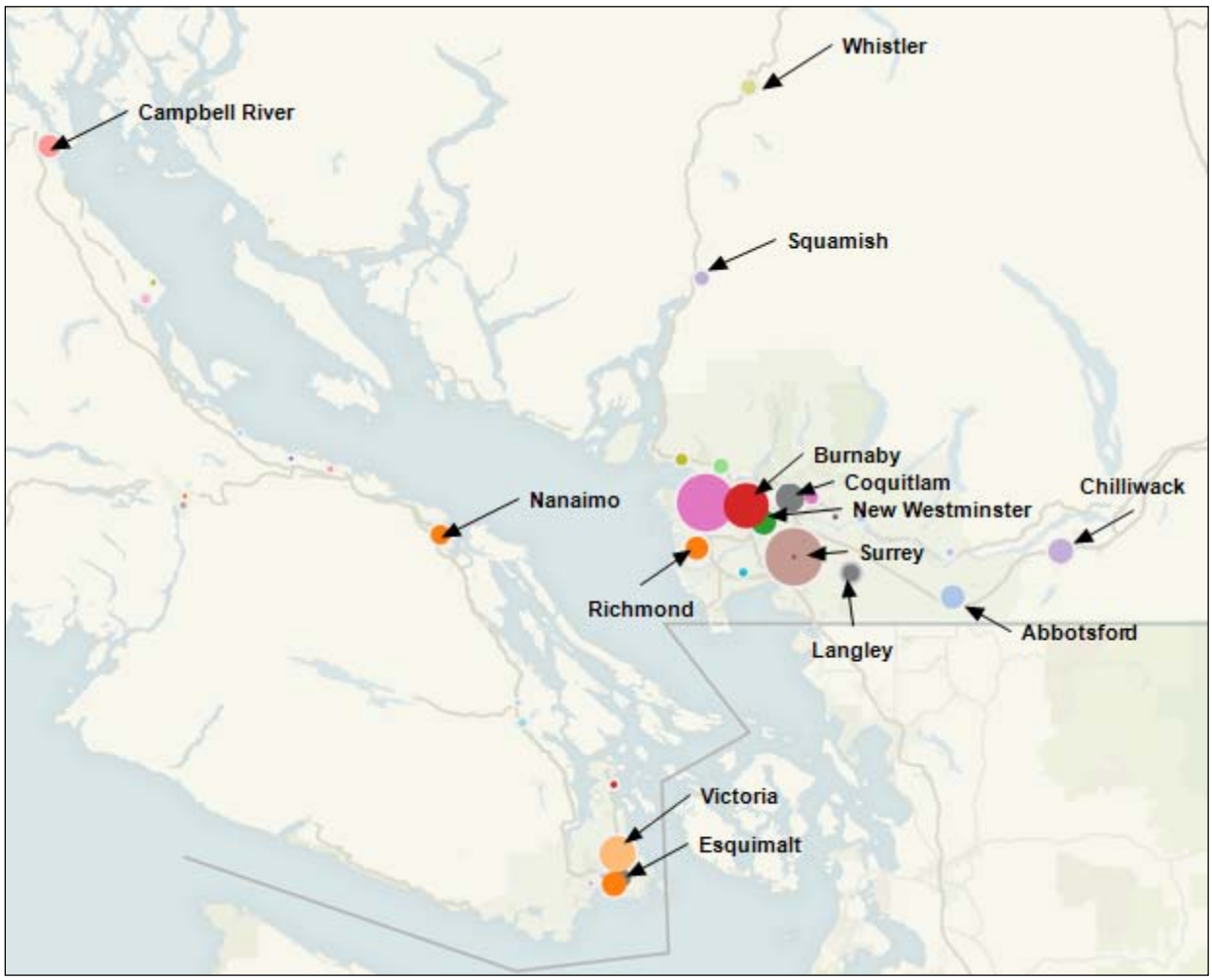

Figure 1 Total Floor Area by City

3.4 Wood Share

In order to provide a baseline for future quantification of the effect of the code change and pro-wood policies we perform an assessment of 2009 wood share[9]. The market share for wood is calculated based on the portion of the construction that falls within BCBC[10] height and area limits for wood buildings (for these limits, see Table 25, Appendix 1). In the case of hybrid buildings (concrete/wood) actual wood areas are computed subtracting the area in concrete from the total floor area.

Overall, where wood is allowed, it has approximately 33% share in the 1-4 storey non-residential segment (Table 10).

Table 10 Wood Share and Floor Areas (sq.ft.) (Allowed by Code, Non-residential, 1-4[11])

	Wood	Grand Total	Wood %
Commercial	**437,873**	**1,629,993**	**27%**
Hotels, motels	125,000	125,000	100%
Motor vehicle services	23,012	172,798	13%
Parking buildings	-	20,000	0%
Private office buildings	51,973	515,356	10%
Public assembly buildings	39,299	39,299	100%
Recreational buildings	51,268	55,364	93%
Restaurants	721	7,521	10%
Retail, wholesale services	17,601	445,245	4%
Shopping centers, plazas	129,000	249,411	52%
Industrial	**-**	**562,390**	**0%**
Agricultural buildings	-	10,000	0%
Manufacturing plants	-	233,715	0%
Processing plants	-	4,000	0%
Warehouse, storage buildings	-	314,675	0%
Institutional	**551,175**	**834,716**	**66%**
Defence, law enforcement buildings	-	48,064	0%
Educational buildings	252,237	309,045	82%
Hospitals	53,464	99,745	54%
Library	7,403	7,403	100%
Medical / welfare buildings	87,634	106,634	82%
Religious buildings	88,503	106,050	83%
Miscellaneous	1,800	1,800	100%
Grand Total	**990,849**	**3,028,899**	**33%**

[9] Operationalized as the proportion of total floor area corresponding to buildings with a wood wall frame (our operationalization of a wood building).
[10] BC Building Code 2006
[11] Hospitals: 1-2 stories

In the multifamily segment, wood has approximately a 75% share. Naturally, the 5 - 6 storey class shows a low share at this point with only three projects built using a wood frame (312,475 sq.ft. in total); however two of these buildings have 1-2 floors below grade, so in actuality they are 4 stories high above grade (Table 11).

Table 11 Wood Share (Residential 1-6)

	Wood Area	Total Area	Share
Multifamily 1-4	1,934,302	2,586,593	74.8%
Multifamily 5-6	312,475	401,471	77.8%
Multifamily 1-6	2,246,777	2,988,064	75.2%

When looking at all buildings, regardless whether wood is allowed or not, the share for wood in non-residential buildings is naturally lower (Table 12)

Table 12 Wood Share (All Buildings*)

	Actual		
	Wood Area	Total Area	Share
Non-Residential 1-4	990,849	8,282,554	12.0%
Multifamily 1-6	2,246,777	2,988,064	75.2%
Total	**3,237,626**	**11,270,618**	**28.7%**

* Regardless of code limitations to the use of wood

3.5 Wood Use

Table 13 Summary of Wood Usage (All Buildings, New & Additions)

	Non-Residential			Multifamily			Total		
	Public	Private	Total	Public	Private	Total	Public**	Private	Total
Total Floor Area (sq.ft.)	4,054,936	6,372,729	10,427,666	214,298	2,982,766	3,197,064	4,269,234	9,355,496	13,624,730
Total Floor Area (m^2)	376,853	592,261	969,114	19,916	277,209	297,125	396,769	869,470	1,266,239
Wood Floor Area (m^2)	27,878	76,048	103,926	16,678	189,722	206,399	44,556	265,770	310,326
Wood Share (% Area)	7.4%	12.8%	10.7%	83.7%	68.4%	69.5%	**11.2%**	30.6%	24.5%
Total Construction Value (billion $)	$ 2.142	$ 0.936	$ 3.078	$ 0.060	$ 0.466	$ 0.526	$ 2.203	$ 1.402	$ 3.604
Wood Construction Value (billion $)	$ 0.084	$ 0.155	$ 0.238	$ 0.060	$ 0.319	$ 0.379	$ 0.144	$ 0.474	$ 0.618
Wood Share (% Value)	3.9%	16.5%	7.7%	100.0%	68.5%	72.1%	**6.5%**	33.8%	17.1%
Total Projects	97	129	226	5	45	50	102	174	276
Wood Projects	32	42	74	5	34	39	37	76	113
Wood Share (% Frequency)	33.0%	32.6%	32.7%	100.0%	75.6%	78.0%	**36.3%**	43.7%	40.9%
Lumber&EWP (MBF)	1,916	3,448	5,364	1,097	12,536	13,633	3,013	15,983	18,997
Lumber (MBF)	1,041	1,944	2,984	723	8,174	8,898	1,764	10,118	11,882
Str Panels (MSF)	3,449	4,561	8,010	770	8,080	8,850	4,219	12,641	16,860
EWP (MBF)	875	1,504	2,380	374	4,361	4,735	1,249	5,866	7,115
NonstrPanels (MSF)	120	172	292	8	121	130	129	293	422
IntDoors (n)	51,750	30,836	82,586	2,243	35,002	37,245	53,993	65,838	119,831
Cabinetry (LF)	4,055	6,348	10,403	1,056	16,471	17,527	5,111	22,820	27,930
CO_2 stored (mT)*	5,052	7,893	12,945	1,995	22,299	24,294	7,048	30,192	37,239
CO_2 avoided (mT)*	4,546	12,100	16,646	4,241	46,500	50,741	8,787	58,600	67,387
Combined CO_2 effect (mT)*	9,598	19,993	29,591	6,236	68,799	75,035	15,834	88,792	104,626
Combined CO_2 effect (cars equiv)*	1,833	3,819	5,652	1,191	13,141	14,332	3,024	16,959	19,984
Regeneration time (min)	104	162	266	42	465	507	146	628	773
Lumber &EWP per capita (BF/cap)	0.42	0.76	1.18	0.24	2.75	2.99	0.66	3.52	4.18
Str. Panels per capita (SF/cap)	0.76	1.01	1.77	0.17	1.77	1.94	0.93	2.79	3.71

* Please refer to Section 2.3 for explanation of these carbon figures. Cars equivalent is one year of emissions from this many cars

** Baseline for wood uptake tracking (For details see Table 26 in Appendix 1). Interior doors reported only as a reference for potential use

3.6 Potential for Growth in Wood Construction

Tables 14 to 16 show an assessment of the annual potential for additional wood construction. This opportunity comes from two sources; buildings that, according to BCBC, could have been built in wood (Table 14), and the use of Heavy Timber (HT) roofs on noncombustible buildings (Tables 15 and 16).

Table 14 Volume from Buildings that Could Have Been Built with Wood

	Non-Residential			Multifamily		Total		
	Public	Private	Total	Private	Total	Public	Private	Total
Floor Area (sq.ft.)	285,329	1,732,721	2,018,050	528,733	528,733	285,329	2,261,453	2,546,782
Lumber&EWP (MBF)	1,111	3,722	4,833	3,195	3,195	1,111	6,917	8,028
Lumber (MBF)	557	2,507	3,063	2,088	2,088	557	4,595	5,152
Str Panels (MSF)	1,040	2,865	3,906	2,021	2,021	1,040	4,886	5,926
EWP (MBF)	554	1,216	1,770	1,107	1,107	554	2,322	2,877
Total-CO_2 stored (mT)*	2,247	6,942	9,189	5,655	5,655	2,247	12,596	14,844
Total-CO_2 avoided (mT)*	4,776	14,754	19,530	12,018	12,018	4,776	26,772	31,548
Total combined CO_2 effect (mT)*	7,024	21,696	28,720	17,672	17,672	7,024	39,368	46,392
Total combined CO_2 effect (cars equiv)*	1,342	4,144	5,485	3,375	3,375	1,342	7,519	8,861
Regeneration time (min)	46	145	191	118	118	46	263	309

* Please refer to Section 2.3 for explanation of these carbon figures. Cars equivalent is one year of emissions from this many cars

This opportunity represents approximately a 50% increase in the demand for wood products with approximately 12% of it coming from the public sector.

Table 15 Total Potential Volume from HT Roofs

	Non-Residential			Residential		Total		
	Public	Private	Total	Public	Private	Public	Private	Total
Roof Area (sq.ft.)	1,273,044	2,246,720	3,519,764	-	20,010	1,273,044	2,266,730	3,539,774
Lumber+EWP (MBF)	3,283	2,769	6,052	-	13	3,283	2,782	6,065
Panels (MSF)	1,673	1,264	2,938	-	9	1,673	1,273	2,946

To avoid double counting, Table 16 shows the net marginal opportunity for HT roofs once subtracted volumes accounted for in Table 14 (buildings that could have been built in wood).

Table 16 Net Marginal Opportunity from HT Roofs

	Non-Residential			Residential		Total		
	Public	Private	Total	Public	Private	Public	Private	Total
Roof Area (sq.ft.)	1,117,271	1,125,304	2,242,575	-	-	1,117,271	1,125,304	2,242,575
Lumber+EWP (MBF)	3,092	1,544	4,636	-	-	3,092	1,544	4,636
Panels (MSF)	1,427	731	2,158	-	-	1,427	731	2,158

Adding things up (Table 14 + Table 16), the annual opportunity for growth in wood consumption is equivalent to: 12,664 MBF of lumber and EWP, and 8,084 MSF of structural panels. If this growth was realized total consumption would be equivalent to 31,661 MBF and 24,964 MSF.

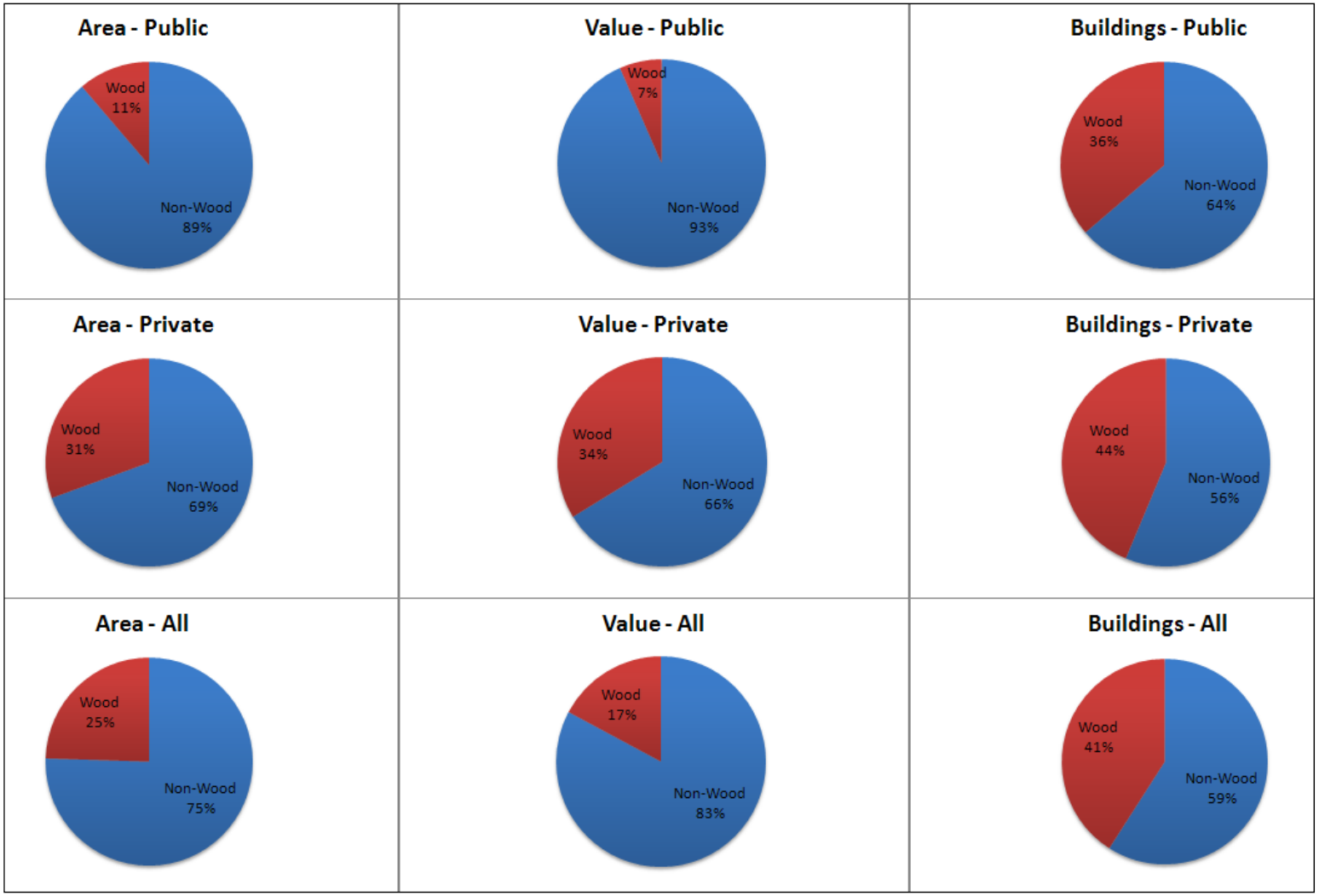

Figure 2 Wood Share by Owner and Metric. All Buildings.

3.7 Qualitative data

A phone/e-mail survey was conducted in order to estimate the volume of wood used in the construction of non-residential and multi-family buildings in British Columbia, as of a start date in 2009. The target participants of the survey were primarily the architects and builders involved in the construction of these buildings. Only those projects where there was uncertainty about the quantitative information were targeted.

The greatest success in terms of attaining reliable data was achieved by contacting the architects.

Although there was some difficulty in contacting the appropriate people, when contact was made, most were able and willing to offer valuable responses. Most preferred to receive the survey by e-mail, fill it out and then return it. Some respondents returned surveys containing obvious errors such as inaccurate building description and even listing the wrong building materials, but many respondents did go to great lengths to ensure all responses provided were accurate and detailed.

Despite the inherent setbacks of phone surveys such as low response rate and unreliable data, the survey was not without its benefits as it provided some interesting insight into prevalent perceptions and attitudes regarding wood as a building material in the industrial and multifamily building sector.

The overall attitude towards use of wood in building systems was very positive. Most architects that were contacted believed wood to be a viable, economical, and eco-friendly material. However, they mentioned that there are limitations regarding the use of wood within building codes, and that the final decision regarding the type of materials used is made by the owner of the project.

Another interesting finding was that in response to inquiring about total volume of wood used for any given project; hardly any respondents were able to offer an answer. Most indicated that it was an invalid question as multiple projects are conducted simultaneously and wood volumes are not kept track of or in many cases even calculated. Most respondents were unable or extremely reluctant to make any kind of estimate regarding wood volumes used. Unless there is a mandate to record this info (e.g., public buildings) it is unlikely that reliable data will be acquired.

Throughout the survey a common concern was pointed out regarding the use of wood as a building material in that buildings such as hospitals, fire halls, police departments, water purification stations, hangars, etc. need to have a post-disaster design. This negatively affects the perception of wood as a viable choice for structural material in such buildings. It was also mentioned that the owner of the building has the last say on the materials used, however their choice is based on durability as the first priority.

Wood was viewed as the least durable when compared to concrete and steel construction.

There were also many concerns regarding moisture issues that are involved in wood construction. Some architects mentioned that most customers they deal with believe that maintenance frequencies and costs are both higher for wood-based structures resulting in much higher overall costs (as compared to concrete and steel), especially over long periods of time.

Another interesting comment was made regarding changes in building codes for wood structures. A few of the architects mentioned that in the future they will consider switching from the multi-material system that they now use which uses concrete for the first floor and then wood for the upper four floors, to all-wood buildings. They mentioned that the main reason they used and continue to use the multi-material

construction system is because of the building code restrictions. However since the building codes have changed since 2009, in the future, they will be looking into using all-wood material for building structures higher than four storeys. It is important to note that this comment was made only regarding multi-family housing; when asked about commercial buildings the response was more complex. The architects were reluctant to use wood as structural components because they were concerned about wood durability and the frequent need for maintenance. There were also concerns regarding flammability of wood versus other material such as concrete.

Some of the respondents mentioned designing a wood building that utilizes engineered wood products (EWP) can be troublesome when it comes to sourcing the material and having it arrive on time at the job site. Local producers are hard to find and in most cases, sourcing material from out of province and US is more costly than using concrete or steel.

In summation, the results of the survey, although having some limitations, give some indication of prevalent attitudes, priorities and procedures in terms of building material choices. These results also highlight common concerns regarding wood as a choice for a primary building material. These concerns include: building codes, durability, costs, sourcing issues, etc.

3.8 Comparison to Other Data

Table 17 provides a comparison to previous studies on wood usage.

Table 17 Comparison of BC 2009 Data to Others (Non-residential, 1-4 storeys)

	BC 2009	BC 2006	K/W 2005[12]	Alberta 2004[13]	USA 2003[14]
Sample size	211	194	47	330	4,273
Average area (sq.ft.)	39,254	37,910	46,921	42,192	38,792
Proportion of buildings <3 storeys	91%	88%	91%	95%	91%
Definition of a wood building	Ext walls	Ext walls and roof	Ext walls and roof	Ext walls and roof	Ext walls and roof
Proportion of buildings that is mostly wood	31%	13%	19%	13%	19%
Proportion of area that is mostly wood	11%	5%	6%	5%	8%
Proportion of value that is mostly wood	17%	6%	6%	5%	8%
Proportion of buildings that is partly wood	NA	27%	36%	25%	--
Proportion of area that is partly wood	NA	23%	22%	13%	--
Proportion of value that is partly wood	NA	28%	13%	12%	--
Proportion of buildings allowed to be wood	76%	80%	81%	84%	84%
Proportion of area allowed to be wood	46%	41%	35%	34%	38%
Proportion of value allowed to be wood	51%	46%	38%	52%	45%

Note: Proportion of market share is on the basis of all 1-4 storey buildings, regardless whether wood is allowed by code or not.

[12] This was a building permit census in the cities of Kitchener and Waterloo, Ontario, as reported in O'Connor 2006b.

[13] This was a building permit census in Calgary, Edmonton and Red Deer, as reported in O'Connor 2006a.

[14] The "allowed to be wood" data shown for the US study are some of the results of FPInnovations' (Forintek) participation in that collaboration, and are lower than those shown in McKeever *et al.* (2006), which were calculated to maximize all possible allowances within the US International Building Code. The figures shown here are a version of the calculation which more closely matches the Canadian National Building Code comparison as performed for BC, Alberta and Kitchener/Waterloo. Note as well that the source data for this work – McGraw-Hill – includes their demarcations of structural frame, and we therefore cannot vouch for the accuracy of those assignments. In other words, what constitutes a "wood" building in the US study may be based on different parameters than the other studies shown here.

4 Discussion and Recommendations

The observed share for wood frame construction in 2009 falls within historical levels for North America. Wood has a clear dominance of the multifamily-apartment market with three quarters of the market. There is plenty room for growing wood share in the nonresidential market.

The advent of new building systems such as CLT may allow wood to capture some share in the industrial category where wood currently has no reported presence.

Where wood is allowed by code, the Institutional category has a 66% share, whereas commercial has only 27%. These numbers may be showing the positive effect on publically-funded buildings of programs in place such as WoodWORKS!

It should be noted that 2009 was also a year with lumber prices at an all-time low so this might have provided a boost to wood as the material choice and therefore create some anomalies when using it as a baseline for uptake tracking. On the other hand, construction levels plunged sharply from 2008.

The data reported here provides a baseline to measure growth post-2009, some (or much) of which will be attributable to the BCBC code change allowing wood in multilfamily buildings up to six storeys, and the Wood First Act. The Wood First Act may particularly accelerate growth in the government office building category, which only had a 9% share for wood in 2009.

The total potential for growth (from project conversion) is estimated at approximately 530,000 sq.ft. for multi-family and 2 million sq.ft. for non-residential, with a 90% concentration in the private industry. This opportunity is equivalent to 8,000 MBF of lumber & EWP and 6,000 MSF of structural panels, increasing demand by 50%, approximately. Furthermore, the use of heavy timber roofs on noncombustible buildings might add an additional 4,600 MBF and 2,200 MSF. These figures are based on wood use in 2009 (a very low construction year), which means that this estimate can be considered a minimum for growth. In terms of carbon, the opportunity from project conversion represents a total combined CO_2 effect of 45,000 metric tons, equivalent to one year of emissions from 9,000 cars.

Architects showed a favorable view towards wood, but identified several factors hindering its use in non-residential construction. These factors are: higher costs over the life cycle of the building due to durability and maintanance costs, code limitations, flammability, and procurement and design difficulties.

It will be valuable to repeat this study periodically as one mechanism for assessing the impact of the Wood First Act and the BC building code height allowance change for wood-frame multi-family buildings. However, it's important to not rely on market share statistics alone as a benchmark for growth initiatives. First, there are multiple factors that influence structural material selection, and fluctuations in share from one year to another may have been caused by any of them. In addition, small sample sizes (a given if the study is done on the scale of a province rather than a national scale) mean a handful of buildings with unusual characteristics can greatly affect the statistics. Our recommendation is to use multiple metrics for baseline comparisons of the program's effectiveness; in addition to actual market share statistics as reported here, attitudinal survey results as well as anecdotal evidence from BC WoodWORKS! field staff are just as valid in providing indications of market transformation. Likewise, wood usage factors should be updated periodically to reflect regional variation and technological changes. It is hoped that initiatives for tracking wood uptake (Wood Enterprise Coalition) will serve this purpose.

See Appendix 2 for specific recommendations for growth initiatives.

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Appendix 1 – Detailed Data

(a) Mixed Use Projects

Mixed use projects comprise approximately 10% of all buildings; however in the multifamily category mixed projects represent 34% of the projects.

Table 18 Frequency of Mixed Projects by # Floors (New construction)

Building Type/Stories	Not Mixed	Mixed	Total
Commercial	**72**	**1**	**73**
1	41		41
2	23	1	24
3	4		4
4	2		2
5	1		1
6	1		1
Industrial	**21**		**21**
1	12		12
2	9		9
Institutional	**64**	**2**	**66**
1	29		29
2	19		19
3	4		4
4	3	1	4
5	3	1	4
6	3		3
7	2		2
10	1		1
Miscellaneous		**1**	**1**
5		1	1
Multifamily	**33**	**17**	**50**
1	1		1
2	2	1	3
3	5	3	8
4	19	11	30
5	1		1
6	2	2	4
7	1		1
9	2		2
Total	**190**	**21**	**211**

(b) Number of Floors

Table 19 Floor Area and Project Frequency by Number of Floors (Non-residential)

Building Type/Stories	Floor Area (sq.ft.)	Projects (n)
Commercial	**2,989,998**	**75**
Hotels, motels	**125,000**	**2**
4	125,000	2
Motor vehicle services	**167,770**	**8**
1	70,930	7
2	96,840	1
Parking buildings	**48,160**	**2**
1	20,000	1
6	28,160	1
Private office buildings	**547,056**	**18**
1	92,562	8
2	218,840	6
3	200,653	3
5	35,000	1
Public assembly buildings	**99,860**	**8**
1	14,900	3
2	74,960	4
3	10,000	1
Recreational buildings	**345,255**	**11**
1	42,298	6
2	302,957	5
Restaurants	**14,800**	**3**
1	14,800	3
Retail, wholesale services	**775,687**	**17**
1	526,290	13
2	249,397	4
Shopping centers, plazas	**866,411**	**6**
1	60,111	2
2	806,300	4
Industrial	**1,574,080**	**21**
Agricultural buildings	**10,000**	**1**
1	10,000	1
Manufacturing plants	**622,743**	**7**
1	71,250	2
2	551,493	5
Processing plants	**4,000**	**1**
1	4,000	1
Retail, wholesale services	**118,651**	**1**
2	118,651	1
Warehouse, storage buildings	**818,686**	**11**
1	595,972	8
2	222,714	3

Table 20 Floor Area and Project Frequency by Number of Floors (Continued, Non-residential)

Building Type/Stories	Floor Area (sq.ft.)	Projects (n)
Institutional	**3,389,978**	**64**
Defence, law enforcement buildings	**63,128**	**3**
1	15,064	1
2	48,064	2
Educational buildings	**1,330,572**	**26**
1	361,239	11
2	383,050	7
3	207,270	3
4	176,114	2
5	16,900	1
6	151,000	1
7	35,000	1
Government office buildings	**116,267**	**11**
1	40,080	7
2	76,187	4
Hospitals	**1,211,704**	**9**
1	14,964	4
3	344,740	1
4	40,000	1
5	188,000	1
6	624,000	2
Library	**7,403**	**1**
1	7,403	1
Medical / welfare buildings	**519,634**	**6**
1	14,634	1
4	30,000	1
5	125,000	2
7	100,000	1
10	250,000	1
Passenger terminals	**17,216**	**1**
1	17,216	1
Religious buildings	**124,054**	**7**
1	13,000	1
2	111,054	6
Miscellaneous	**23,000**	**1**
Miscellaneous	**23,000**	**1**
5	23,000	1

Table 21 Floor Area and Project Frequency by Number of Floors (Continued, Residential)

Building Type/Stories	Floor Area (sq.ft.)	Projects (n)
Multifamily	**3,197,064**	**50**
1	40,020	1
2	79,803	3
3	195,896	8
4	2,270,875	30
5	54,252	1
6	347,219	4
7	28,000	1
9	181,000	2
Grand Total	**11,174,120**	**211**

Table 22 Wood Used by Remy Project

Expected Wood Volumes*				
Lumber	771,428	BF		
Panels	841,093	sq.ft.		
Engineered I-joists	80,052	LF		
EWPs	164,560	kg		
Subtotal BF equivalent				
Subtotal sq.ft. panels 3/8"				
Assumptions				
1 LF I-joist=	2	BF lumber		
SPF density @ 20%	450	kg/ m^3	(480 kg/ m^3 EWP)	
1 m^3	565	BF (EWP)		
1 sq.ft. panels	0.5	BF		
1 m^3	424	BF (solid)		
Usage factors (FPInnovations)				
Lumber	3.93	BF/ sq.ft.		
Panels	4.29	BF/ sq.ft.		
Engineered I-joists	0.82	BF/ sq.ft.		
EWPs	0.98	BF/ sq.ft.		
Subtotal BF equivalent	5.74	BF/ sq.ft.		
Subtotal sq.ft. panels 3/8"	4.29	BF/ sq.ft.		

* David Fisher and Canfor

Note: As part of the lessons learnt from Remy, future projects may consider some changes in configuration which will likely cause the estimated usage factors to vary. These changes include a wider distance on center for the studs on the ground level to provide enough room for utilities (e.g., going from 2x4, 8" OC to 2x6 16" OC). Also, using party walls as shear walls every other unit rather than on all party walls.

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Table 23 Wood Usage Factors by Building Size, Frame Material and Type (BF or sq.ft. per 1,000 sq.ft.)

Lumber&EWP	Size	Region	Frame			
	<50k			>50k		
	U.S.			U.S.		
Type	Concrete	Metal	Wood	Concrete	Metal	Wood
All	641	436	3,568	61	68	2,993
Colleges	768	739	7,788	21	259	6,219
Health	303	627	3,166	17	130	1,817
Hotels	1,447	2,238	5,321	-	265	5,191
Industrial	318	116	2,399	60	13	-
Misc	402	295	874	104	185	923
Offices	1,485	643	4,782	11	36	2,733
Public	503	282	4,005	136	208	2,290
Recreation	735	486	2,675	77	44	1,657
Religious	717	634	4,593	84	77	3,175
Schools	1,707	532	2,924	262	102	3,613
Stores	272	323	2,607	19	45	1,494
Apartments	941	1,454	6,173	-	172	6,000

Str Panels	Size	Region	Frame			
	<50k			>50k		
	U.S.			U.S.		
Type	Concrete	Metal	Wood	Concrete	Metal	Wood
All	937	664	3,528	241	305	2,731
Colleges	2,047	516	8,161	894	325	1,752
Health	1,541	1,301	3,902	707	1,384	2,834
Hotels	1,399	3,782	7,206	-	253	5,437
Industrial	309	129	1,621	21	2	-
Misc	262	689	704	418	31	-
Offices	1,299	1,209	4,133	714	63	1,434
Public	1,303	444	3,167	475	181	-
Recreation	1,162	905	2,441	880	711	1,434
Religious	1,848	353	4,667	42	466	481
Schools	2,527	496	2,727	163	347	4,131
Stores	465	600	2,538	120	274	701
Apartments	909	2,458	4,684	-	165	3,534

Lumber	Size	Region	Frame			
	<50k			>50k		
	U.S.			U.S.		
Type	Concrete	Metal	Wood	Concrete	Metal	Wood
All	260	190	1,969	41	46	2,230
Colleges	326	188	4,848	19	208	6,151
Health	132	193	1,326	16	20	1,494
Hotels	803	1,081	3,205	-	108	3,047
Industrial	34	52	1,653	18	13	-
Misc	208	111	537	8	120	923
Offices	768	235	2,199	9	18	2,733
Public	122	98	2,093	57	43	2,290
Recreation	302	199	1,539	20	25	1,583
Religious	107	181	3,243	52	8	3,175
Schools	756	468	1,985	225	89	2,264
Stores	96	158	1,331	12	37	1,485
Apartments	522	703	4,100	-	70	3,900

EWP	Size	Region	Frame			
	<50k			>50k		
	U.S.			U.S.		
Type	Concrete	Metal	Wood	Concrete	Metal	Wood
All	381	246	1,599	19	22	763
Colleges	442	552	2,939	1	51	68
Health	170	434	1,840	2	109	323
Hotels	644	1,157	2,116	-	157	2,144
Industrial	285	64	746	41	0	-
Misc	194	184	337	96	64	-
Offices	717	408	2,583	3	19	-
Public	382	184	1,911	79	165	-
Recreation	433	287	1,135	57	18	74
Religious	610	453	1,351	32	69	-
Schools	951	64	938	37	13	1,349
Stores	176	165	1,276	8	7	10
Apartments	419	752	2,073	-	102	2,100

	sq.ft./door	sq.ft./LF
Type	Int. Doors	Cabinetry
Colleges	200	1,000
Health	90	1,000
Hotels	70	1,000
Industrial	-	1,000
Misc	200	1,000
Offices	200	1,000
Public	200	1,000
Recreation	16	1,000
Religious	400	1,000
Schools	700	1,000
Stores	600	1,000
Apartments	80	170

	Lumber		Panels	
Wood Roof	<50k	>50k	<50k	>50k
Colleges	336	1,356	295	1,029
Health	179	2,250	176	630
Hotels	490	1,656	330	1,076
Industrial	315	61	-	-
Misc	192	555	392	-
Offices	832	2,569	1,340	12
Public	1,482	2,117	1,283	-
Recreation	809	1,728	598	826
Religious	2,482	2,534	2,277	322
Schools	1,206	1,394	1,435	1,358
Stores	1,034	1,042	517	413
Apartments	319	1,076	215	699

Source: Adapted from McKeever et al. 2003, RSMeans and Remy project.

Note: Parameters for interior doors and cabinetry modified from RSMeans.

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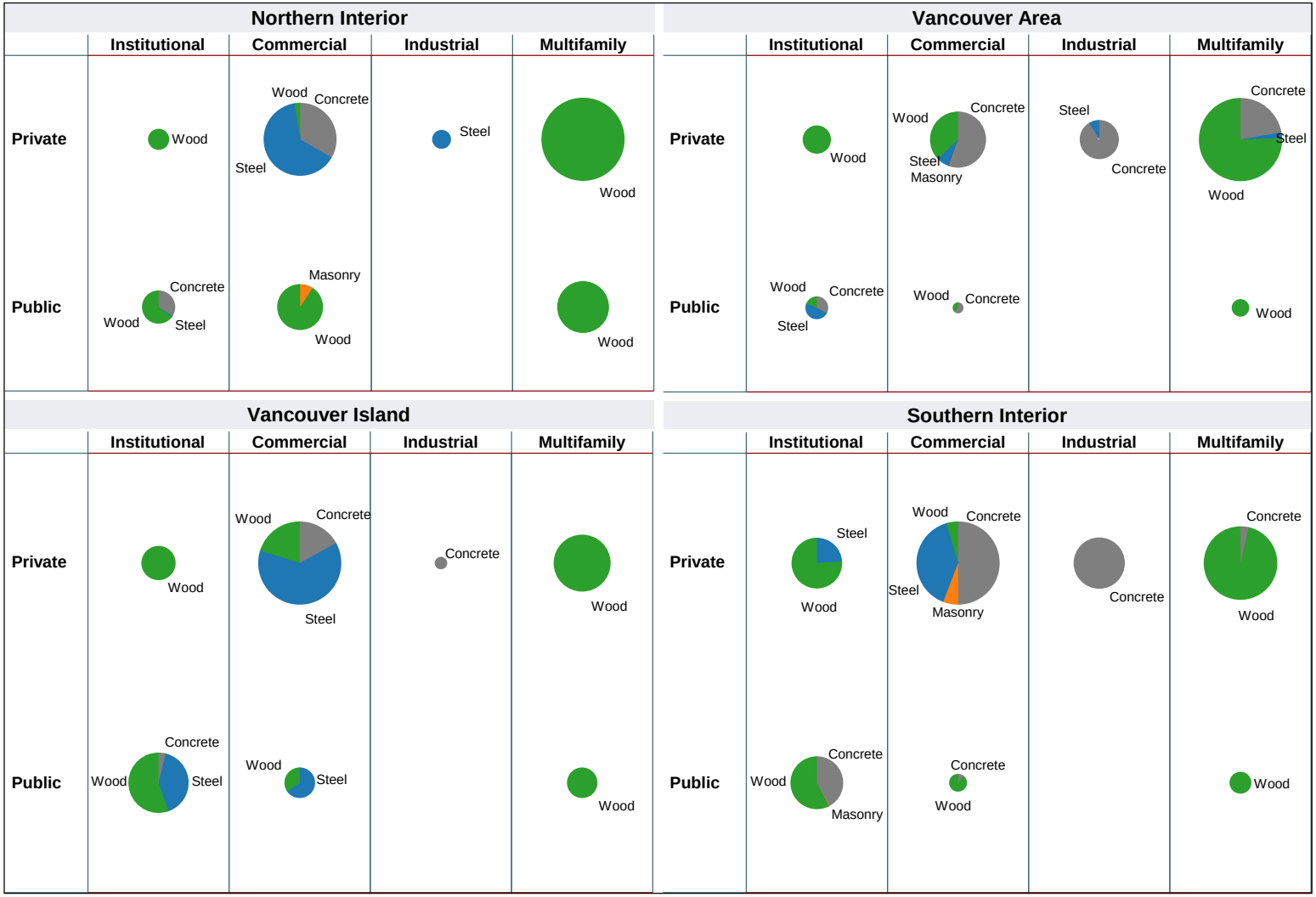

Figure 3 Low Rise Construction by Zone (Where wood is allowed by code)

$$Ext.Walls = \sqrt{\frac{SF/Sto}{Str}} * 4 * SH * Sto * Str * (1 - par\ Windows)$$ [square feet]

$$Partitions = \frac{SF}{par\ Part} * PH$$ - Doors area [square feet]

$$Roof = \frac{SF/Sto}{Str} = Footprint$$ [square feet]

$$Elev.Floors = Footprint * (Sto - 1) * Str$$ [square feet]

$$Floor\ Area\ Wood\ (mixed) = Footprint\ * (Sto - 1)$$ [square feet]

$$Windows = Ext.Walls * par\ Windows$$ [units]

$$Moulding = \frac{SF}{par\ Part} + \sqrt{\frac{SF/Sto}{Str}} * 4 * Sto * Str$$ [Lineal Feet]

Cabinets: See Table 22, Appendix 1.

Figure 4 Formulas and Parameters Used in the Calculation of Assembly Footages

Legend:
SH: Storey height (feet, RSM)
Sto: # Stories (n)
Str: Number of structures (n)
Doors area: Area of door openings (3'x 7' doors, as per parameter for door density (sq.ft./unit))
PH: Partition height (LF, RSM)
Par Part: Parameter for partition walls (sq.ft. per LF of partition, RSM)
Moulding: Only baseboards (floor/wall) included (residential and commercial) (only referential)
Par Windows: Parameter for windows (% of exterior walls, RSM)
RSM: Average values from RSMeans
Note: 1 LF=0.3048 m; 1 sq.ft.=$(0.3048\ m)^2$ =0.0929 m^2, or 1 m^2=10.76 sq.ft.

Table 24 Parameters Used in the Calculation of Environmental Indicators

Plywood	404	kg/m^3	70%	Ratio approx. from McKeever 2003, Density from Cdn plywood Assocn.
OSB	544	kg/m^3	30%	Ratio approx. from McKeever 2003, Density from Cdn plywood Assocn.
Average panels (w)	446	kg/m^3		Weighted average
Lumber	416	kg/m^3		Forintek SP-24R p.40
Average EWP (w)	489	kg/m^3	Glulam/I joists (OSB web)/LVL/PSL&LSL (12/55/6/27)	
wood mass (kg) to C:	0.5			Literature
BF lumber to m^3:	617.18			Random Lengths
C to CO_2	3.67			Ratio of molecular weights
displacement factor:	3.9	Low/mid rise LWF		Source: Sathre O'Connor 2010
Car ghg emmisions	0.191	mT/year		USEPA 2010
sq.ft. to m^3	0.000885			3/8 basis
BF/ft^3	16			
ft^3/m^3	35.3			
Vol logs	44.1%	Yield Factor		
Vol trees	10%	Log to Tree volume factor		
Annual growth US/Can	452,768,796	m^3/yr net		UNECE
Annual growth BC	80,000,000	m^3/yr net		
BC population	4,554,085			BC Stats 2010

Table 25 Code Allowances by Building Type

	Max Area for Wood Construction						***Max Area for HT Roof on Noncombustible Building***	
Sprinklered (footprint, m^2)	**Floors**						***Sprinklered (footprint, m^2)***	
Type	1	2	3	4	5	6	1	2
Assembly (A2)	600	0	0	0	0	0	Unlimited	Unlimited
Health (B2)	2,400	1,600	0	0	0	0	Unlimited	Unlimited
Residential (C)	7,200	3,600	2,400	1,800	1,440	1,200	Unlimited	Unlimited
Business (D)	14,400	7,200	4,800	3,600	0	0	Unlimited	Unlimited
Retail (E)	7,200	3,600	2,400	1,800	0	0	Unlimited	Unlimited
Industrial (F1)	3,600	1,800	1,200	0	0	0	4,500	9,000
Industrial (F2)	9,600	4,800	3,200	2,400	0	0	Unlimited	Unlimited
Industrial (F3)	14,400	7,200	4,800	3,600	0	0	Unlimited	Unlimited

HT: Heavy Timber

Table 26 Wood Usage by Public Building Type. All Floors

Use	Type	Type detail	Number (n)	Wood Floor Area (sq.ft.)	Total Floor Area (sq.ft.)	Wood Share (%)	Lumber & EWP (MBF)	Str. Panels (MSF)	Total combined CO_2 effect (mT)
Commercial	**Total**	**Total**	**30**	**60,786**	**1,447,118**	**4%**	**419**	**1,130**	**2,219**
	Parking buildings	Parkade	1		20,000		8	5	14
	Private office buildings	Office	1	1,200	1,200	100%	6	5	35
		Office / Warehouse	1		21,757		14	26	37
	Public assembly buildings	Art Centre	1	5,900	5,900	100%	24	19	138
		Community Centre	1	3,519	3,519	100%	14	11	82
		Community Hall	1		20,000		6	9	14
		Convention Centre	1		419,000		57	199	216
		Cultural Centre	2	21,380	21,380	100%	86	68	500
		Library	1	7,500	7,500	100%	30	24	175
		Museum / Art Gallery	1		10,000		3	4	7
		Other	1	1,000	1,000	100%	4	3	23
	Recreational buildings	Arena	2		218,416		28	193	172
		Clubs and Lodges	1	10,000	10,000	100%	27	24	163
		Gymnasium	1		17,500		13	20	31
		Recreation Centre	11	10,087	516,908	2%	93	476	570
		Public Washroom	2	200	252	79%	1	1	3
	Retail, wholesale services	Retail Store	1		152,787		7	42	38
Institutional	**Total**	**Total**	**67**	**239,185**	**2,607,818**	**9.2%**	**1,495**	**2,318**	**7,149**
	Defence, law enforcement buildings	Correctional Facility	1		15,064		8	20	24
		Police Station	2		48,064		24	63	77
	Educational buildings	Child Day Care	2	7,690	7,690	100%	22	21	137
		Elementary School	4	44,948	91,539	49%	190	205	933
		High School	1	11,147	11,147	100%	33	30	198
		Middle School	1	1,150	1,150	100%	3	3	20
		Office	1		125,354		13	44	47
		Research Facility	2	15,000	21,048	71%	47	44	272
		Trade School	1		17,141		29	43	69
		University	12	27,656	779,889	4%	429	466	1216
	Government office buildings	Fire Hall	13	29,579	105,335	28%	229	218	1037
		Office	7	10,685	409,853	3%	80	95	382
		Police Station	1	3,723	3,723	100%	18	15	107
	Hospitals	Health Care	1	4,304	4,304	100%	14	17	93
		Hospital	13	8,500	869,498	1%	74	721	729
	Library	Library	1	7,403	7,403	100%	30	23	173
	Medical / welfare buildings	Health Care	1	45,000	45,000	100%	142	176	977
	Passenger terminals	Bus Terminal	2		22,216		6	10	15
	Religious buildings	Church	1	22,400	22,400	100%	103	105	642
Multifamily	**Multifamily**	**Multifamily**	**5**	**179,451**	**214,298**	**84%**	**1,097**	**770**	**6,117**
Grand Total			**102**	**479,421**	**4,269,234**	**11%**	**3,010**	**4,217**	**15,485**

Table 27 List of Abbreviations

BF	Board foot
CAD	Canadian dollar
EWP	Engineered wood products
k	Thousand square feet
LF	Lineal foot
MBF	Thousand board feet
MSF	Thousand square feet
mT	Metric tonnes
Sq.ft.	Square foot

Table 28 Construction Activity by Year (BC)

		Floor Area (000 sq.ft.)				Change from previous year			
		Commercial	Industrial	Institutional	Total Nonres.	Commercial	Industrial	Institutional	Total Nonres.
2003	British Columbia	7,752	1,102	3,553	12,407				
2004	British Columbia	8,384	1,777	5,199	15,360	8%	61%	46%	24%
2005	British Columbia	11,850	1,861	5,413	19,124	41%	5%	4%	25%
2006	British Columbia	9,509	2,051	4,947	16,507	-20%	10%	-9%	-14%
2007	British Columbia	8,316	1,150	4,752	14,218	-13%	-44%	-4%	-14%
2008	British Columbia	6,142	1,485	2,671	10,298	-26%	29%	-44%	-28%
2009	British Columbia	4,284	355	3,442	8,081	-30%	-76%	29%	-22%
2010	British Columbia	5,710	450	4,529	10,689	33%	27%	32%	32%

						Change from previous year		
		Multifamily Starts[1]	Multifamily Area[2]	Nonres. Area[3]	Total	Multifamily	Nonres.	Total
2007	British Columbia	72,000	29,000	14,218	43,218	N/A	N/A	N/A
2008	British Columbia	84,000	15,000	10,298	25,298	-48%	-28%	-41%
2009	British Columbia	48,000	6,000	8,081	14,081	-60%	-22%	-44%
2010	British Columbia	N/A	12,000	10,689	22,689	100%	32%	61%

[1] CHMC, [2,3] Reed

Proposed Displays to Track Wood Use

In addition to the use of tables the graphs below (mock-ups) may be illustrative as means of tracking the progress and or effect of policies such as the Wood First Act. In future reports, we propose to include graphs like these to demonstrate wood use by Province, geographic zone, building category and building type[15].

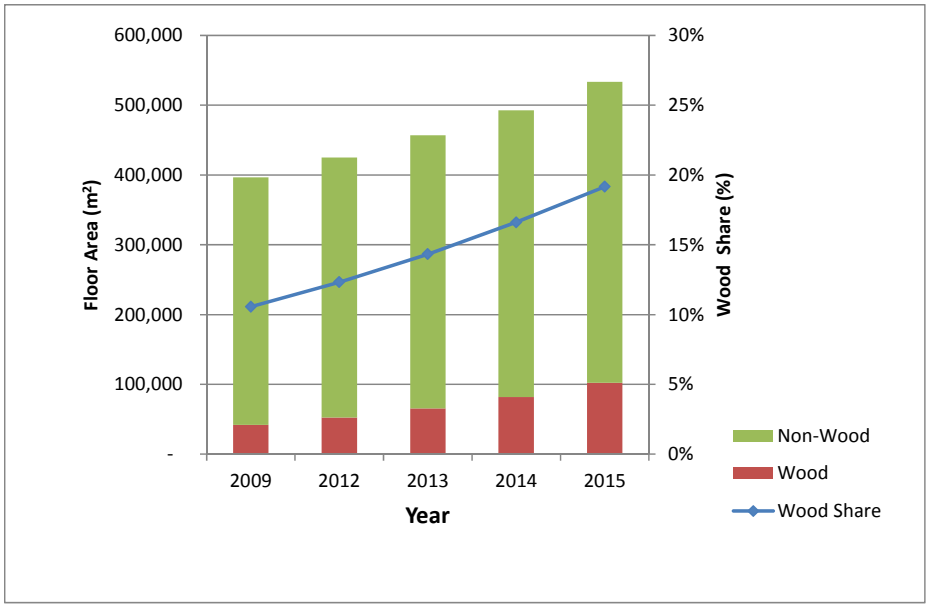

Figure 5 Proposed Display to Track Wood Share (Area, Value, Buildings)

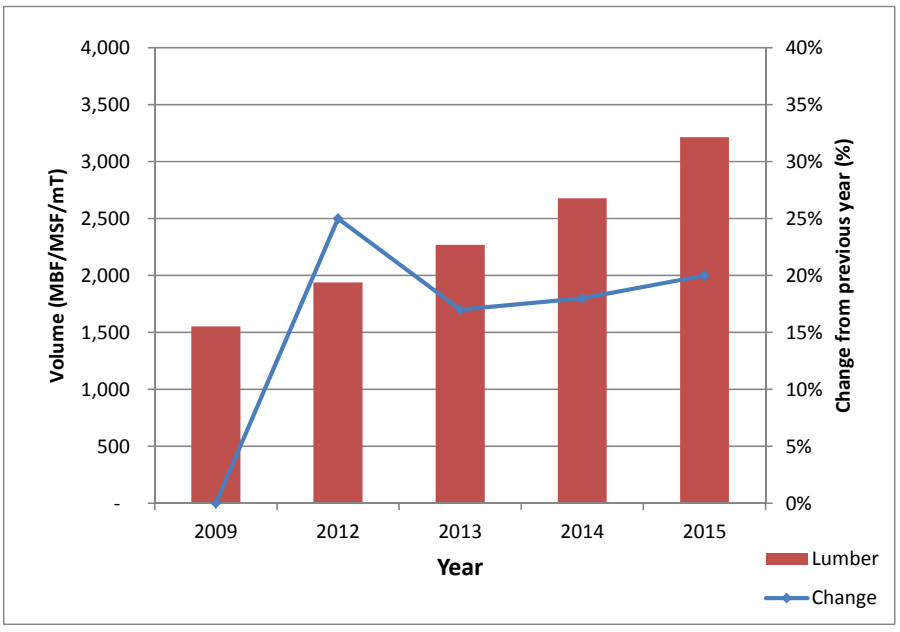

Figure 6 Proposed Display to Track Wood Uptake and CO_2 Effect

[15] It may be advisable to include previous years to 2009 as a reference to historic levels

Appendix 2 – Recommendations for Market Growth

BC has a substantial opportunity to increase domestic wood product consumption via greater share of the non-residential construction market, similar to every other region in North America. The likelihood of success in a market growth campaign in non-residential may depend on several factors outside of the influence of the campaign, such as construction sector economics. In other words, if wood structural systems are not cost-competitive (in all costs related to products, design professional labour, installation labour, insurance and so forth), then any shift in the marketplace towards wood conversions will be relatively small. The construction sector is almost entirely dominated by cost concerns. Where there are sector issues or questions around the cost effectiveness of wood systems, a wood promotional campaign can perhaps be most affective by addressing those concerns directly.

Marketplace attitudes towards wood are also an important area of potential influence by a growth campaign. Previous attitudinal research in BC (CV Marketing Research 2004a,b) shows BC architects and engineers identifying many of the same wood concerns as seen elsewhere in North America, such as structural and durability performance of wood systems. Where there are misperceptions about wood's performance capabilities, or where there is a lack of knowledge and experience on how best to design with wood, a promotional campaign can perhaps be an effective source of education.

BC architects identified the client as a driver in the decision on structural systems. This suggests there is value in promotionally targeting building owners/developers, as BC WoodWORKS! has successfully done in various government projects. The challenge is to effectively influence the private sector clients, who may be far else responsive to a campaign based on public good.

Design professionals are often aware that the building code nominally allows wood in many buildings, however, they identify other types of barriers related to code compliance which are important to address in a promotional campaign. For example, design details to achieve fire-rated assemblies are considered difficult by some architects, and they identify this as an area where they would welcome detailed technical assistance.

BC architects and engineers, like designers everywhere, have indicated a desire for very practical and thorough application information that will help make wood design easier for them and help them sell the idea of wood buildings to their clients. For example, detailed cost studies of various building types and wood construction systems, including buildings that use new and innovative structural approaches; detailed case studies of wood buildings describing what worked and what didn't; and design details of complex assemblies and connections. FPInnovations' CLT Handbook and CLT Primer are some examples of such studies.

Best Bets

Recommendations described here were developed as a composite of previous non-residential market research by FPInnovations (Forintek) and others, and information learned from previous focus groups in BC.

Best sectors

- A2 occupancies – restaurants, universities, churches, community centres, indoor recreation, museums, libraries, transit stations. Two storeys and under allowed to be combustible.

- Senior's homes/Assisted living – but only if classified as C occupancy (residential) and not B (health care). Four storeys and under allowed to be combustible.

- D occupancy – offices, clinics, banks, government buildings, salons. Four storeys and under allowed to be combustible.

- E occupancy – strip malls, small stores, "lifestyle" outdoor shopping centers. Four storeys and under allowed to be combustible.

- F occupancies – warehouses, small showrooms, gas stations, broadcast studios, possibly some small factories if low hazard and low abuse. Four storeys and under allowed to be combustible.

Favourability by size

- Practitioners are most comfortable considering wood in buildings two storeys and less, and fairly small in area – definitely under 50,000 square feet, and more likely at an upper limit around 20,000 square feet.

Recommendations for near-term activity

Choose the right targets for conversion to wood

- The construction sector is most favourable to wood in small and simple buildings – no more than 2 storeys in height and 20,000 square feet in area are the easiest targets.
- Building types viewed most favourably for wood include offices, shops, restaurants, community centres, university classrooms, indoor recreation, multifamily, hotels and assisted living.
- The target is architects, engineers, contractors and owners operating within those best-bet sectors.
- Develop one-on-one relationships with the targets in each municipal region. Personal relationships with practitioners allow two-way communication, using work currently in their offices as a vehicle. Very specific hurdles for wood can be better understood, which may help shape future directions of the WoodWORKS! program.

Provide project-specific technical assistance and communications

- Gaining market share for wood is achieved building-by-building, and is dependent on early intervention and then technical assistance during design, for both the architect and the engineer.
- Practitioners are most interested in education when it has immediate relevance to current workload. Maintaining regular contact with the targets assists in tailoring the communication.
- Deliver lunch-and-learn seminars tailored to the specific needs of each office. Bring in specialist assistance, and consider developing some of the seminars into fact sheets for broader dissemination. Example topics of current interest include: Building codes and wood; Wood and LEED; Cost effectiveness of wood buildings/ wood products and systems; Mould and durability; Specific performance issues, such as long span structural, thermal, acoustic.
- Document every project involving communication with WoodWORKS! – each of these is a valuable case study experience that can help shape the future activity of the program.

Foster change by providing real-world examples

- The construction sector wants to see several precedents before it makes change – show them that wood can work with clear case studies specific to each region.
- The showpiece buildings are inspiring for architects, but may not be helpful in capturing a large share of the non-residential market – balance out with case studies of everyday buildings.

- Create these documents by studying and then recording successful uses of wood in each region, with the intention of motivating duplication by other practitioners. This includes all-wood buildings as well as wood hybrids. These brief and focused case studies should capture the project team's perspective of why wood was used and how the team dealt with any wood-specific difficulties. Every case study should include an accurate account of the costs, as well as the code compliance situation. These are not coffee-table brochures; these are reference materials for practitioners. This process is also a mechanism for better understanding market advantages and disadvantages of wood, and can help shape future activity by WoodWORKS!.
- Consider creating a real-world example directly, by providing financial incentive to consider a wood alternative to a non-wood project currently in design. The Wood Enterprise Coalition (WEC) could offer to carry the costs of providing an alternate design in wood, and would additionally assist in a cost comparison and in clarifying the pros and cons of both designs. This may be an attractive method for a building type that is more difficult to convert to wood – large or complex buildings, long span buildings, schools.

Continue with general education and "inspiration" activities, and extend beyond designers

- The designer's client – the owner – has the ability to drive a decision for wood. Commercial-sector developers as well as government clients should be targeted with messages that reference Canadian cultural heritage related to wood; cost-effectiveness and durability of wood buildings; the merit of leaving behind an architectural legacy for the community; the added market value of an attractive wood showpiece; and the increase in worker productivity in well-designed and pleasing buildings.
- The environmental benefits of wood can be a stronger sales tool for wood than currently in place, with architects especially, but also with some owners. Seminars and fact sheets about the use of wood with LEED, and assurances around Canadian sustainable forestry practices, would be helpful.
- Award-winning buildings with exposed wood structure are an architect's dream but beyond the budget of most projects – this is the conventional wisdom of most practitioners. More architects would use structural wood aesthetically if they were shown affordable examples.

Future Work

Take a deeper look at some of the hurdles to wood and consider options to address them

- Questions around product availability, delivery times, quality, and suitability for non-residential applications require some investigation. A market growth program is dependent on the ability of the wood industry to meet any new demand.
- Difficulties with building code requirements are always identified as the biggest hurdle to wood. Nominal area and height limits allow most buildings to be wood, however, there are various aspects to code compliance which nonetheless act as deterrents. For example, achieving fire-rated assemblies, restrictions on combustibles in plenums, and generating unwanted attention from a building code official are just a few of the issues architects may face with wood. It would be useful to engage help from a code consultant to better understand this topic and how it affects the activities and performance of WoodWORKS!.
- Improvements in general information resources such as design manuals, software, web sites and help lines have been flagged in the past as necessary. Specific improvements should be explored in detail.