DURABILITY OF CA- AND ACQ-TREATED CANADIAN WOOD SPECIES IN STAKE AND DECKING TESTS

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Summary

Field tests of stakes in ground contact were established at two locations in Canada (Maple Ridge, BC and Kincardine, ON) to assess the performance in service of three species treated with six retentions of copper azole type B (CA-B), and two species treated with six retentions of alkaline copper quat type D carbonate formulation (ACQ-D). The stakes were visually inspected annually for decay and termite attack up to six years of exposure. While decay and termite attack were well advanced in untreated controls, CA-B-treated samples remained in excellent condition. ACQ-D retentions standardized by CSA were in excellent condition. Early stages of decay were present in ACQ-D-treated stakes at the lower retentions at Maple Ridge. Termite attack, other than surface nibbling, at the Kincardine site was confined to the untreated controls.

Based on these data and data from a parallel test of naturally durable woods, old-growth western redcedar will not give anywhere near the same service life in ground contact as wood preservative-treated to meet CSA O80 standards.

Field tests of decking under natural weathering conditions were established at two locations in Canada (Maple Ridge BC and Petawawa ON) to assess the performance of three species, both untreated, and incised and unincised/treated with three retentions of CA-B, as well as two species treated with ACQ-D. These were visually inspected for decay after five years of exposure. ACQ- and CA-treated Pacific silver fir and spruce and CA-treated jack pine decks meeting CSA O80 for above-ground exposure were completely sound. All but two of the lower retention treated boards were free of confirmed fungal attack. Of the untreated boards, four out of 30 Pacific silver fir and three out of 30 white spruce contained early stages of decay.

1. Introduction

The wood preserving industry in Canada and the US voluntarily phased out the use of chromated copper arsenate (CCA) for most residential uses effective January 1, 2004 after CCA had been the accepted standard preservative for wood in residential use for over thirty years. To replace CCA, copper/co-biocide formulations have been registered with the Pest Management Regulatory Agency (PMRA) of Health Canada. PMRA requires in-service efficacy data for full registration of new preservatives. FPInnovations' field testing program is acknowledged as an unbiased source of such data by both the government and treating industry.

In order to fulfill the PMRA requirements for data in support of their application for registration of their copper azole product (CA-B), Arch Wood Protection Canada Corp. (now a division of Lonza) approached FPInnovations (then operating as Forintek Canada Corp.) to set up ground contact stake tests and above-ground decking exposure tests at locations in Canada representing conditions typical of a coastal and continental climate. Similarly, Timber Specialties Co. and Viance LLC (then operating as Chemical Specialties Inc.) approached FPInnovations to set up tests of their amine copper quat type D (carbonate) product (ACQ-D). This report describes the results of inspections of the stakes after six years in test, and the five-year evaluation of decks.

One year prior to the stake tests being installed at the Maple Ridge test site, a similar test had been set up to evaluate the comparative durability of a range of naturally durable wood species (Morris *et al.* 2011). Since this is a rare example of naturally durable and preservative-treated wood of the same dimensions being tested over a similar time period at the same test site, some of the data from that work is presented here for comparison purposes.

2. Materials and Methods

2.1 Stakes

The stake tests were based on the method described in AWPA E7-08 (AWPA 2008).

2.1.1 Stake Preparation

Eight-ft 2x4 inch kiln-dried boards of jack pine (*Pinus banksiana* Lamb.), Pacific silver fir (*Abies amabilis* Dougl. Forbes), and white spruce (*Picea glauca (*Moench), Voss) were obtained, high-density incised at Western Wood Preservers, Aldergrove BC, and cross-cut into 1 m long double-length stakes. These were pressure-treated at FPInnovations' Vancouver laboratory with a range of solution strengths designed to meet the target retentions. The treatment process used a 30 minute vacuum of at least 25 mm of mercury, a 1.5 hour pressure period at 1035 kPa for Pacific silver fir, and 4 hours' pressure for jack pine and white spruce, and a final 15 minute vacuum of at least 25 mm of mercury. For CA-B, jack pine, Pacific silver fir, and white spruce were tested. Pacific silver fir and white spruce were used in the ACQ-D study. These two species represent opposite ends of the range of treatability of Canadian species but not the extremes of maximum and minimum treatability. After treatment the double-length stakes were covered with lumber wrap for 10 days then unwrapped to dry prior to installation at the test sites. After 10 days of drying an analysis biscuit was crosscut from the centre of each double length stake for analysis of preservative retention and penetration. This created two 0.46 m end-matched daughter stakes, one for installation at each site.

2.1.2 Stake Installation

Based on the analysis results, 10 end-matched stakes (20 daughter stakes) from each target retention/species group were selected to average as closely as possible the target retention. A total of 420 end-matched CA-B-treated stakes were installed at the test plots (10 replicates x 6

retentions x 3 species and 10 untreated controls x 3 species at each test site). For the ACQ-D study a total of 280 end-matched stakes were selected for installation at each test plot comprising 10 replicates x 6 retentions x 2 species plus 10 untreated controls x 2 species at both test sites.

The stakes were installed in June 2005 at FPInnovations' test sites at Maple Ridge, BC, near Vancouver, and Kincardine, ON, near Toronto. Stake holes were pre-drilled using a 6 inch powered auger. To offset variations in soil conditions within the much larger Maple Ridge test site the stakes were split between the four quadrants of this test site. Their locations within each plot were randomized, and a map was prepared.

Test Sites

The site at Maple Ridge is located within the University of BC Malcolm Knapp Research Forest. The soil is a sandy silt loam to a depth of 0.3 m. It has a pH around 5.1 and has relatively high organic matter (approximately 18%). Below this is a layer of fine- to coarse-grained sand with some gravel and silt. In summer, groundwater is between 0.5 and 2.4 m below grade. This site has a rainfall of 2150 mm per year, and mean daily maximum and minimum temperatures of 6°C and 1°C in January, and 23°C and 12°C in July, with an average yearly temperature of 9.6°C. It falls within the moderate decay hazard zone for outdoor above-ground exposure using Scheffer's climate index (Scheffer 1971; Setliff 1986), with an updated climate index of 63 (Morris and Wang 2008). This zone includes most of the major population centres of North America.

The Kincardine test site is located within the town of Kincardine on the shore of Lake Huron. The soil is a sandy loam. This site receives mean annual precipitation of 998 mm and has mean daily maximum and minimum temperatures of -2°C and -10°C in January, and 24°C and 13°C in July with an average yearly temperature of 6.2°C. The climate there places it within the zone of medium out-of-ground decay hazard with an updated climate index of 49 (Owen Sound data). This test plot also has a population of the subterranean termite *Reticulitermes flavipes* Kollar.

2.1.3 Stake Inspection

In June 2011 in Kincardine and August 2011 at Maple Ridge, each stake was removed from the soil, loose grass and dirt were brushed off then it was examined visually for indications of decay such as the presence of fungal mycelium or discolouration. If decay was suspected, the area of interest was gently probed with a metal scraper. Each specimen was then assigned a rating, based on the new AWPA E7 grading systems, for decay at both sites and termite attack at Kincardine:

Decay Rating	Condition	Description
10	Sound	No sign or evidence of decay, wood softening, or discoloration caused by microorganism attack.
9.5	Trace-suspect	Some areas of discolouration and/or softening associated with superficial microorganism attack.
9	Slight attack	Decay and wood softening is present. Up to 3% of the cross sectional

		area affected.
8	Moderate attack	Similar to “9” but more extensive attack with 3-10% of cross sectional area affected.
7	Moderate/severe attack	Sample has between 10-30% of cross sectional area decayed.
6	Severe attack	Sample has between 30-50% of cross sectional area decayed.
4	Very severe attack	Sample has between 50-75% of cross sectional area decayed.
0	Failure	Sample has functionally failed. It can either be broken by hand due to decay, or the evaluation probe can penetrate through the sample.

Termite Attack Rating	Description
10	Sound.
9.5	Trace, surface nibbles permitted.
9	Slight attack, up to 3% of cross sectional area affected.
8	Moderate attack, 3-10% of cross sectional area affected.
7	Moderate/severe attack and penetration, 10-30% of cross sectional area affected.
6	Severe attack, 30-50% of cross sectional area affected.
4	Very severe attack, 50-75% of cross sectional area affected.
0	Failure.

For each stake at Kincardine the lower of either the decay or the termite rating was used to calculate a mean termite/decay rating.

2.2 Decking

The decking tests were based on an FPinnovations in-house method since standardized as AWPA E25-08 (AWPA 2008).

2.2.1 Deck Preparation

Eight-ft 2x6 inch kiln-dried boards of three species, white spruce (*Picea glauca*), jack pine (*Pinus banksiana*), and Pacific silver fir (*Abies amabilis*), were obtained and half of the boards were high-density incised at Western Wood Preservers Aldergrove BC. They were then pressure-treated at the FPInnovations Vancouver laboratory with a range of solution strengths of CA-B designed to hit the three target retentions. For ACQ-D, white spruce and Pacific silver fir were treated. The treatment process was as described above, with the exception that the pressure period used was 2 hours for incised boards and 1 hour for unincised boards for all species. After a minimum of 10 days post-treatment, the 40 8-ft deck boards per retention level were cross-cut to produce two end-matched 0.6 m replicates, one to be installed at Maple Ridge and the other at

Petawawa. In addition, from each of the 40 boards per retention level samples were taken for preservative penetration (individually) and retention measurement (pooled for the 20 boards per deck). A total of 42 CA-B-treated decks were constructed: (Maple Ridge and Petawawa) x 3 solution strengths x 3 species x 2 incised/non-incised, and one untreated deck x 3 species x 2 sites. A total of 28 ACQ-D-treated decks were constructed: (Maple Ridge and Petawawa) x 3 solution strengths x 2 species x 2 incised/unincised, plus one untreated deck per species per site.

Figure 1 Deck Design

Each deck base consisted of six 2x6 inch treated boards placed on edge and screwed together to form a frame, as shown in Figure 1. The cut ends of deck base boards and half of the experimental deck boards were brush-coated with two applications of copper naphthenate (2% copper) field-cut preservative. The decks were constructed using stainless steel screws, with the experimental deck boards pre-drilled with two holes near each end and attached in two rows of ten replicates to the frame (Figure 1). One row consisted of boards with end-cut preservative, while the other was uncoated. A stainless steel tag was attached to the deck base to identify each unit, and each of the 20 boards had an identifying number on the underside of the board. The decking modules were constructed at FPInnovations and then shipped to the field test sites.

2.2.2 Test Sites

The decks were mounted on levelled concrete blocks in areas at FPInnovations' test sites at Maple Ridge, BC, near Vancouver, and Petawawa, ON, near Ottawa, in October 2004.

The Maple Ridge test site was described above. The Petawawa test site is located within the Petawawa Research Forest of Natural Resources Canada near Ottawa, ON. It is cleared natural forest surrounded by mixed coniferous/deciduous trees and has mean daily maximum and minimum temperatures of -7°C and –18°C in January, and 25°C and 13°C in July, with an average yearly temperature of 4.3°C. It receives mean annual precipitation of 822 mm. The climate there also places it within the zone of medium out-of-ground decay hazard with a climate index of 48 (Morris and Wang 2008).

2.2.3 Inspection of Test Material

After five years in test, each board of the twenty per deck was individually assessed for decay using the AWPA E25-08 rating system:

Rating	Condition of the board
10	Sound: no evidence of decay.
9.5	Trace or suspicion of decay.
9	Minor softening on end-grain or on sides of checks. Up to 3% of cross-section decayed.
8	Small pockets of decay on end-grain or on sides of checks. Less than 10% of cross-section decayed.
7	Moderate decay. Sample has between 10-30% of cross-section decayed.
6	Severe attack. Sample has between 30-50% of cross-section decayed.
4	Very severe decay likely to affect load-bearing capacity but not readily broken.
0	Failure when stepped on sharply by a person of moderate weight (60–80 kg). This could be by breakage of the board or severe surface collapse.

The presence of a fruitbody generated an automatic rating of no higher than 8 on the basis that the fungus must have degraded a substantial volume of wood to produce the fruitbody.

The inspection method involved gentle probing of checks and end-grain with a metal spatula for signs of softening or cavities. Particular attention was paid to areas of high moisture content, discolouration, or collapse visible on the surface, and areas sounding hollow or dull when tapped with the blunt end of the spatula. The weather was dry at Maple Ridge but wet at Petawawa during the inspections. This can influence the appearance and softness of the wood.

3. Results and Discussion

3.1 Stakes

3.1.1 Untreated stakes

At Maple Ridge, of the untreated control stakes, six white spruce, five Pacific silver fir, and one jack pine had failed due to fungal attack during the six years of exposure, while at Kincardine seven white spruce, five Pacific silver fir, and two jack pine untreated stakes had failed due to either fungal or termite attack. Although untreated jack pine had suffered less damage than untreated stakes of the other two species, decay was firmly established. When a combined termite/decay rating was determined for the Kincardine stakes, the performance of the untreated species was comparable to that at Maple Ridge. The rate of decay of the untreated controls was relatively slow in this test compared to other published work. This is likely due to a number of reasons. This work used nominal 2 by 4 stakes rather than smaller sizes permitted by AWPA E7-04, it used lumber containing heartwood and sapwood instead of just pure sapwood, the high soil moisture content at Maple Ridge may favour soft-rot fungi, and the low soil moisture content at Kincardine may favour termites rather than the wood-rotting basidiomycetes that would normally attack and decay untreated wood very rapidly. In several cases the drop in mean decay rating of controls was initially rapid then slowed down. This is likely due to early failure of some stakes to wood-rotting basidiomycetes leaving the remaining stakes to fail more slowly to soft-rot fungi.

3.1.2 CA-B-treated stakes

In contrast to the untreated controls decay and, at Kincardine, termite attack in CA-B-treated stakes was negligible. Stakes treated to the retention specified for ground contact in CSA O80 Series-08, 3.3 kg/m^3, had ratings of 9.9 or 10 for all three species at both sites. Mean ratings did not fall below 9.3 even for the lower two retentions on all three species at both test sites (Figures 2-7, Tables 1-3). There was some minor termite nibbling on the surface of treated stakes at the Kincardine site demonstrating the termite pressure at this site. These stakes were rated 9.5 and the termite attack did not progress.

Table 1 Performance of CA-B-treated Pacific silver fir stakes

Target Retention (kg/m³)	Retention By Analysis (kg/m³)[1]	Edge Penetration (mm)		Six-Year Ratings			
		% ≥ 8	% ≥ 10	Decay Maple Ridge	Decay Kincardine	Termite Kincardine	Termite/Decay Kincardine
0.0	-	-	-	3.2 (3.4)	4.0 (4.2)	4.1 (3.2)	2.8 (3.1)
0.6	0.65	70	70	9.6 (0.4)	9.8 (0.3)	9.9 (0.3)	9.7 (0.3)
1.0	1.02	100	100	9.4 (0.7)	9.9 (0.3)	10.0 (0.0)	9.8 (0.3)
1.5	1.53	100	100	9.9 (0.3)	10.0 (0.2)	10.0 (0.2)	9.9 (0.2)
2.2	2.29	90	90	9.9 (0.2)	10.0 (0.0)	10.0 (0.2)	10.0 (0.2)
3.3	3.32	100	100	10.0 (0.0)	10.0 (0.2)	10.0 (0.0)	10.0 (0.2)
5.0	5.10	100	100	10.0 (0.0)	10.0 (0.0)	10.0 (0.2)	10.0 (0.2)

[1] As copper metal - assay zone of 16 mm. Standard deviations are given in parentheses.

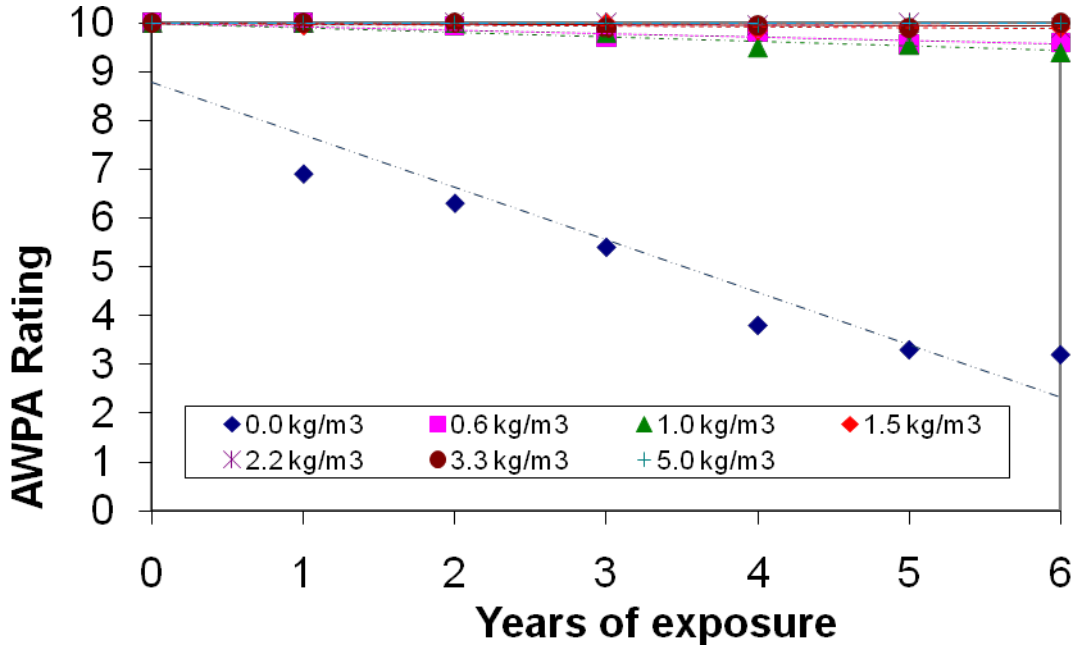

Figure 2 Performance (decay) of CA-B-treated Pacific silver fir stakes at Maple Ridge

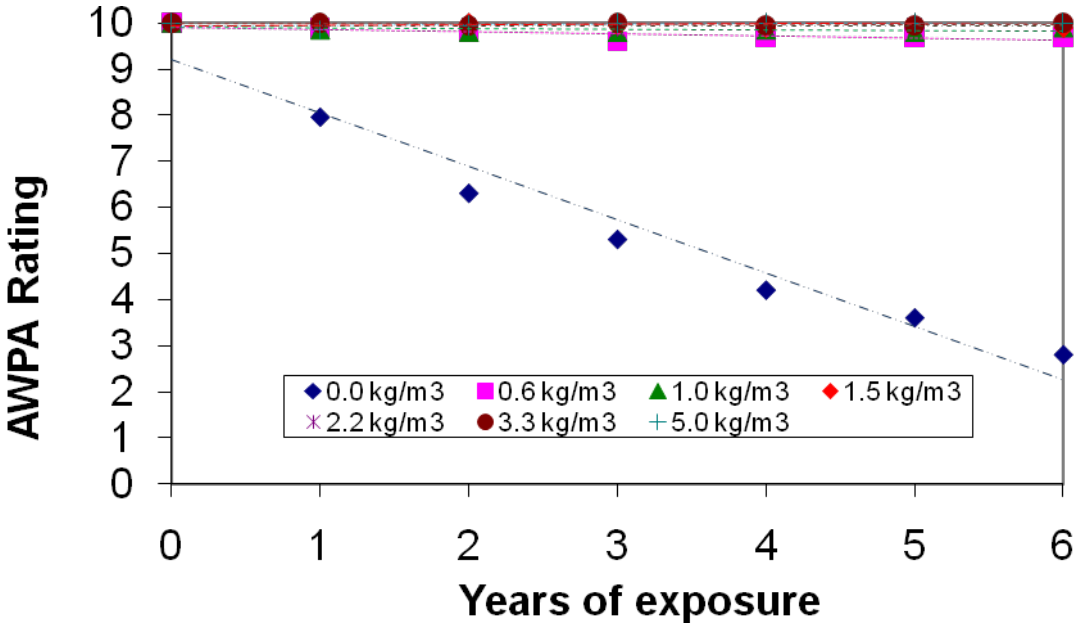

Figure 3 Performance (combined decay/termite) of CA-B-treated Pacific silver fir stakes at Kincardine

Table 2 Performance of CA-B-treated jack pine stakes

Target Retention (kg/m³)	Retention By Analysis (kg/m³)[1]	Edge Penetration (mm)		Six-Year Ratings			
		% ≥ 8	% ≥ 10	Decay Maple Ridge	Decay Kincardine	Termite Kincardine	Termite/Decay Kincardine
0.0	-	-	-	6.1 (2.5)	5.7 (3.1)	7.0 (1.9)	4.9 (2.8)
0.6	0.76	30	30	9.3 (0.6)	10.0 (0.2)	9.9 (0.2)	9.8 (0.3)
1.0	1.24	30	20	9.9 (0.2)	10.0 (0.0)	10.0 (0.2)	10.0 (0.2)
1.5	1.84	80	30	9.9 (0.3)	10.0 (0.0)	10.0 (0.2)	10.0 (0.2)
2.2	2.43	70	40	10.0 (0.2)	10.0 (0.2)	10.0 (0.0)	10.0 (0.2)
3.3	3.23	100	60	9.9 (0.3)	10.0 (0.2)	10.0 (0.2)	9.9 (0.2)
5.0	4.86	100	91	10.0 (0.0)	10.0 (0.0)	10.0 (0.0)	10.0 (0.0)

[1] As copper metal - assay zone of 16 mm. Standard deviations are given in parentheses.

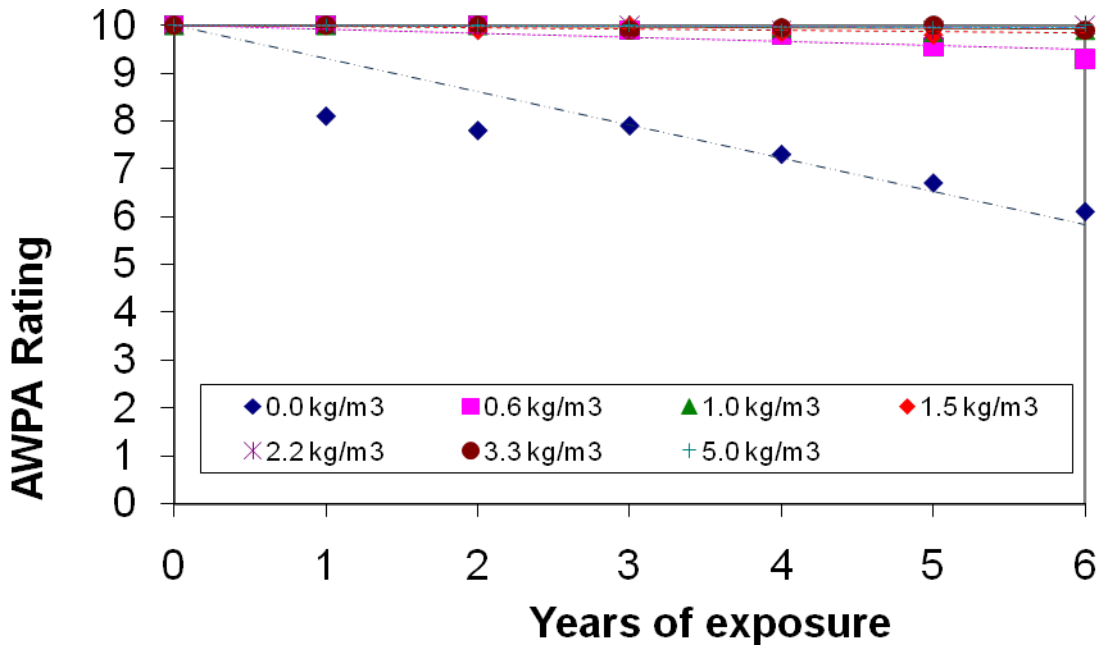

Figure 4 Performance (decay) of CA-B-treated jack pine stakes at Maple Ridge

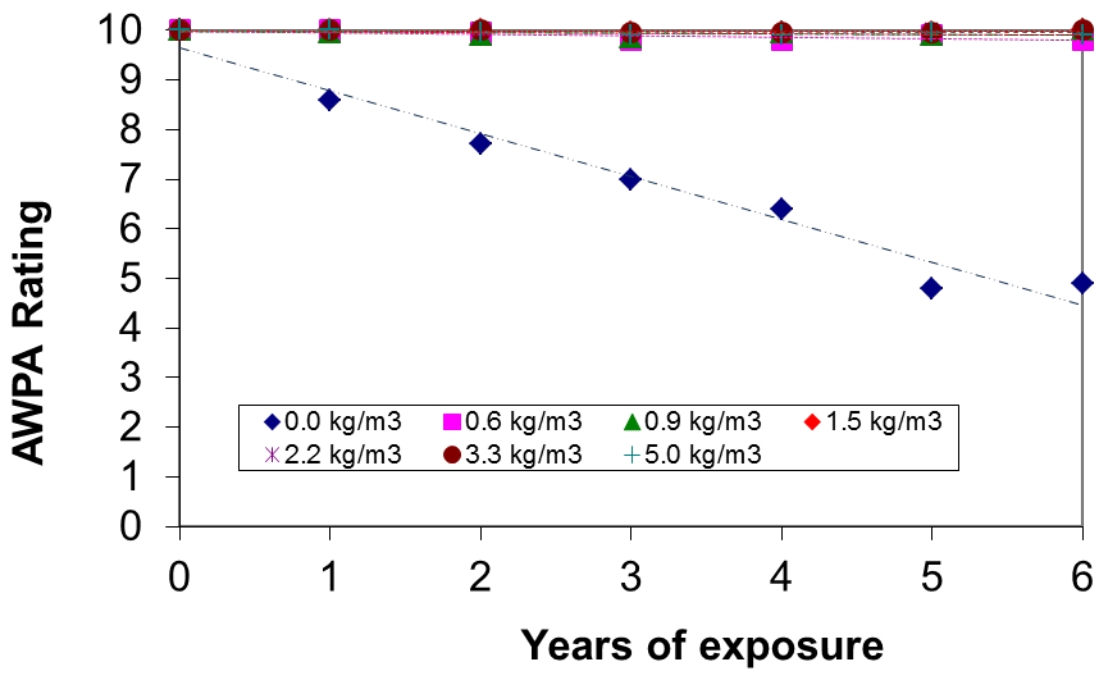

Figure 5 Performance (combined decay/termite) of CA-B-treated jack pine stakes at Kincardine

Table 3 Performance of CA-B-treated white spruce stakes

Target Retention (kg/m³)	Retention By Analysis (kg/m³)[1]	Edge Penetration (mm)		Six-Year Ratings			
		% ≥ 8	% ≥ 10	Decay Maple Ridge	Decay Kincardine	Termite Kincardine	Termite/Decay Kincardine
0.0	-	-	-	2.5 (3.2)	2.3 (3.7)	1.9 (3.1)	1.9 (3.1)
0.4	0.37	0	0	9.6 (0.5)	10.0 (0.2)	9.9 (0.2)	9.9 (0.2)
0.6	0.61	0	0	9.5 (0.5)	10.0 (0.0)	9.9 (0.3)	9.9 (0.3)
1.0	1.08	0	0	9.6 (0.5)	10.0 (0.0)	10.0 (0.2)	10.0 (0.2)
1.5	1.54	10	0	9.7 (0.4)	10.0 (0.0)	10.0 (0.0)	10.0 (0.0)
2.2	2.42	10	0	9.9 (0.3)	10.0 (0.0)	10.0 (0.2)	10.0 (0.2)
3.3	3.79	10	0	9.9 (0.3)	10.0 (0.0)	10.0 (0.0)	10.0 (0.0)

[1] As copper metal - assay zone of 16 mm. Standard deviations are given in parentheses

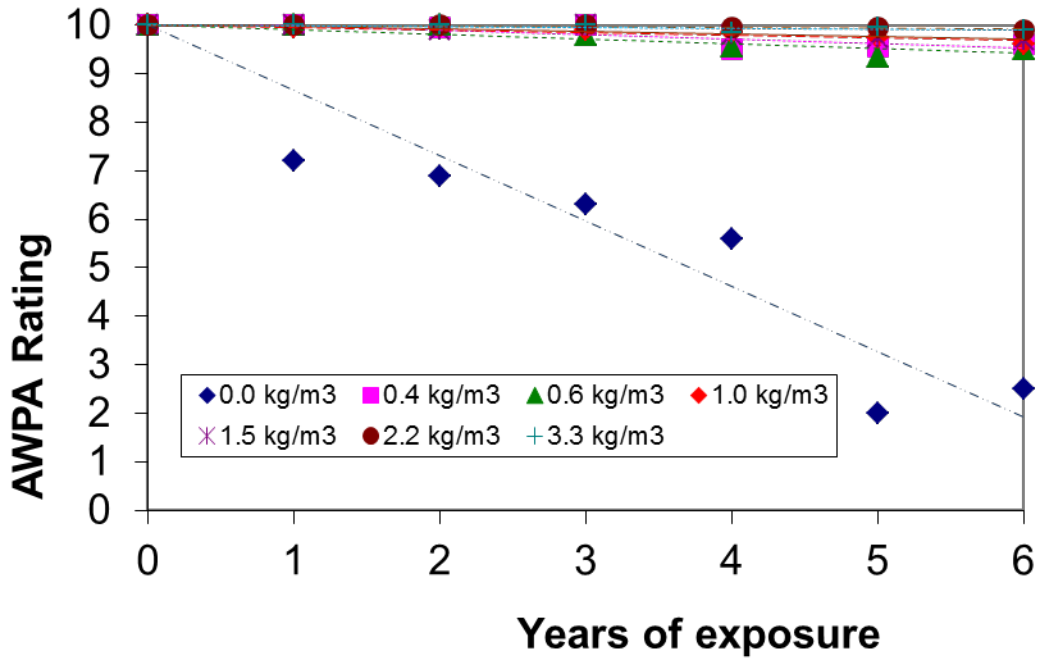

Figure 6 Performance (decay) of CA-B-treated white spruce stakes at Maple Ridge

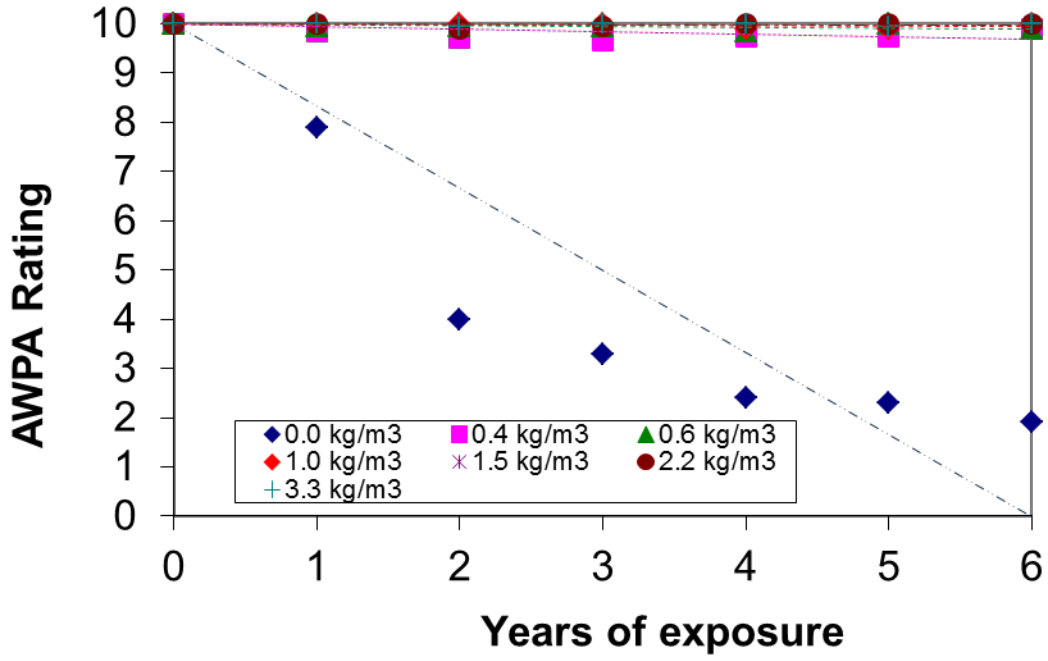

Figure 7 Performance (combined decay/termite) of CA-B-treated white spruce stakes at Kincardine

3.1.3 ACQ-D-treated stakes

Stakes treated to the retention specified for ground contact in CSA O80 Series-08, 6.4 kg/m^3, had ratings of 9.5 and higher for both species at both sites. However, there were early signs of decay on the lower retentions at Maple Ridge with a clear dose response (Figures 8-11 Tables 4-5). Very little confirmed decay or termite attack was found at Kincardine with combined ratings of 9.7 or higher even at the lowest retention in test.

Table 4 Pacific silver fir stakes treated with ACQ-D

Target Retention (kg/m³)	Retention By Analysis (kg/m³)[1]	Edge Penetration (mm)		Six-Year Ratings			
		% ≥ 8	% ≥ 10	Decay Maple Ridge	Decay Kincardine	Termite Kincardine	Termite/Decay Kincardine
0.0	-	-	-	3.2 (3.4)	4.0 (4.2)	4.1 (3.2)	2.8 (3.1)
1.3	1.24	100	100	8.6 (0.6)	9.8 (0.3)	9.8 (0.3)	9.7 (0.3)
1.9	2.20	100	100	8.8 (0.6)	10.0 (0.2)	9.9 (0.2)	9.9 (0.2)
2.8	3.04	100	100	8.8 (0.4)	9.9 (0.2)	10.0 (0.2)	9.9 (0.2)
4.3	4.35	100	100	9.2 (0.4)	10.0 (0.2)	10.0 (0.2)	9.9 (0.2)
6.4	5.74	100	100	9.5 (0.5)	10.0 (0.0)	10.0 (0.0)	10.0 (0.0)
9.6	9.10	100	100	9.5 (0.5)	10.0 (0.2)	9.9 (0.2)	9.9 (0.2)

[1] Assay zone of 16 mm. Standard deviations

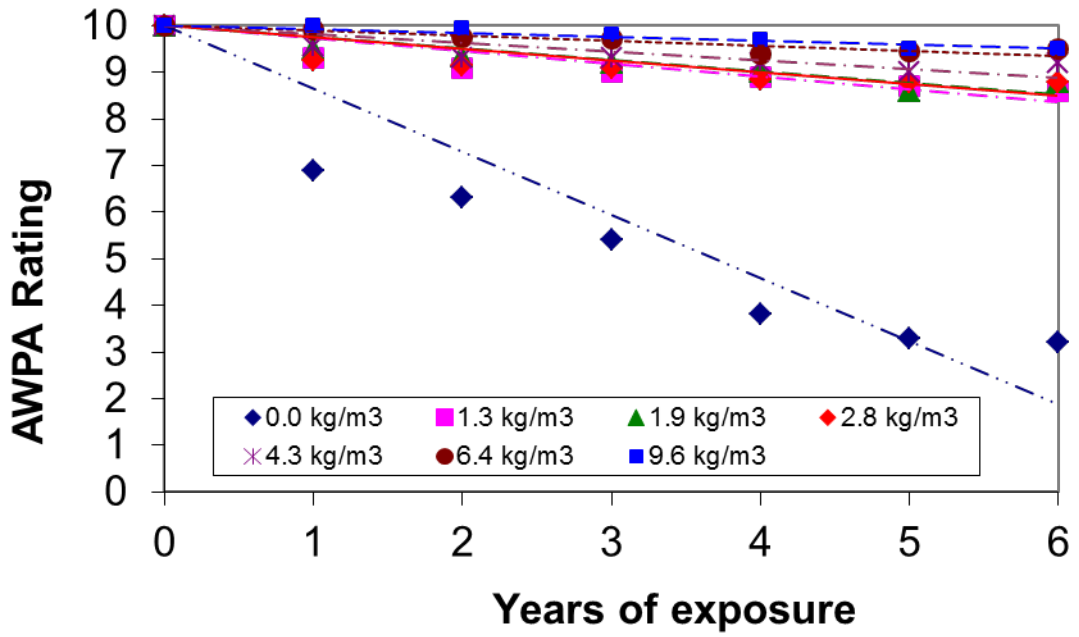

Figure 8 Performance of ACQ-D-treated Pacific silver fir stakes at Maple Ridge

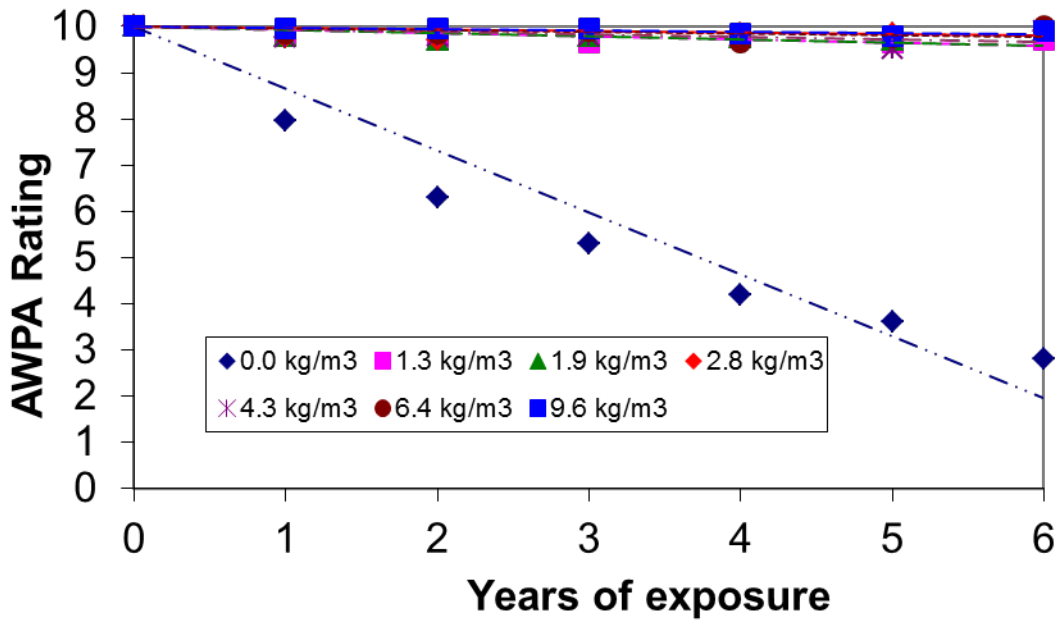

Figure 9 Performance (combined termite/decay) of ACQ-D-treated Pacific silver fir stakes at Kincardine

Table 5 White spruce stakes treated with ACQ-D

Target Retention (kg/m³)	Retention By Analysis (kg/m³)[1]	Edge Penetration (mm)		Six-Year Ratings			
		% ≥ 8	% ≥ 10	Decay Maple Ridge	Decay Kincardine	Termite Kincardine	Termite/Decay Kincardine
0.0	-	-	-	2.5 (3.2)	2.3 (3.7)	1.9 (3.1)	1.9 (3.1)
0.8	0.98	0	0	8.3 (0.7)	9.8 (0.3)	9.8 (0.3)	9.7 (0.3)
1.3	1.71	0	0	8.8 (0.4)	9.8 (0.4)	10.0 (0.0)	9.8 (0.4)
1.9	2.06	20	0	8.9 (0.5)	10.0 (0.2)	10.0 (0.0)	10.0 (0.2)
2.8	2.91	80	40	9.0 (0.4)	10.0 (0.2)	10.0 (0.2)	10.0 (0.2)
4.3	4.60	30	20	9.2 (0.6)	10.0 (0.2)	10.0 (0.0)	10.0 (0.0)
6.4	6.68	60	20	9.6 (0.5)	9.9 (0.2)	10.0 (0.0)	9.9 (0.2)

[1] Assay zone of 16 mm. Standard deviations given in parentheses

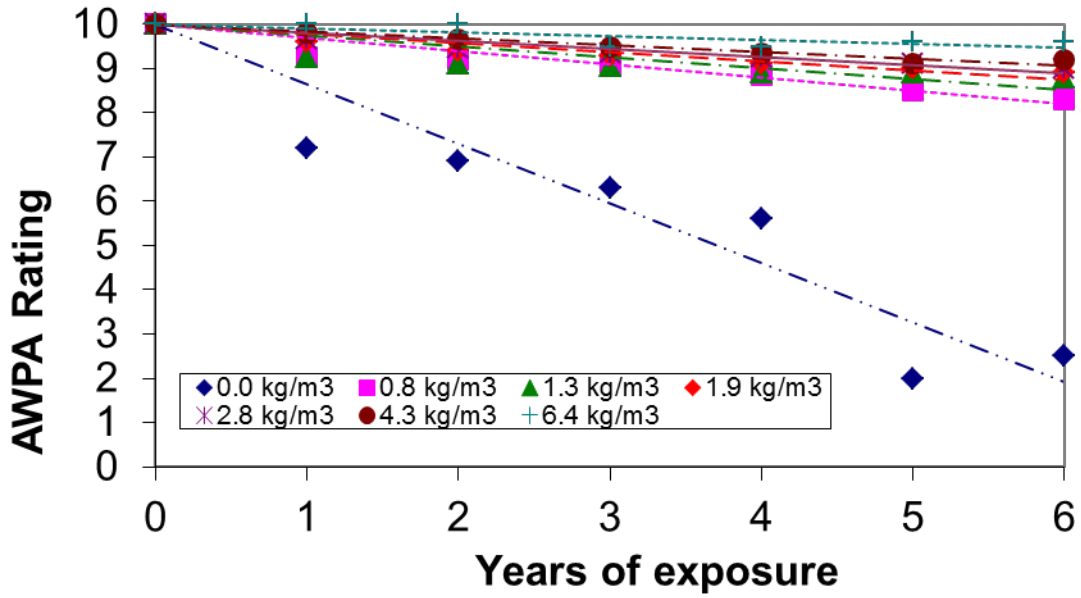

Figure 10 Performance of ACQ-D-treated white spruce stakes at Maple Ridge

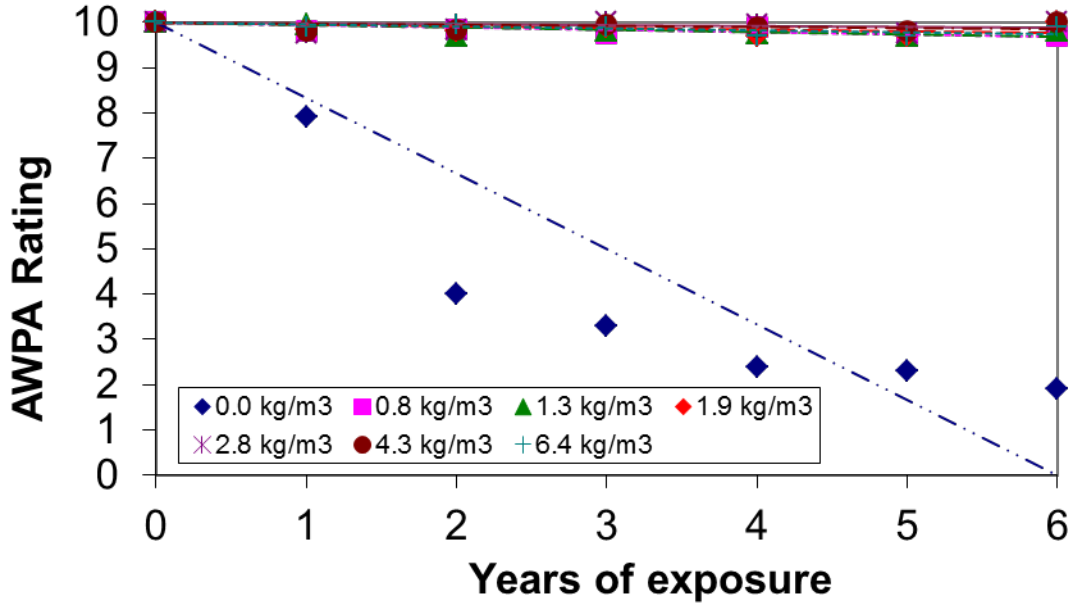

Figure 11 Performance (combined decay/termite) of ACQ-D-treated white spruce stakes at Kincardine

3.2 Comparison of Treated Wood to Naturally Durable Wood

Data from a similar test of naturally durable woods at Maple Ridge (Morris *et al.* 2011) were compared to the retention of CA-B listed for ground contact applications by CSA O80 Series-08. Old-growth western redcedar was decaying much slower than untreated wood but much faster than the treated wood. Fence contractors in the Vancouver area already had this figured out because they have been using treated wood posts and western redcedar panels for years.

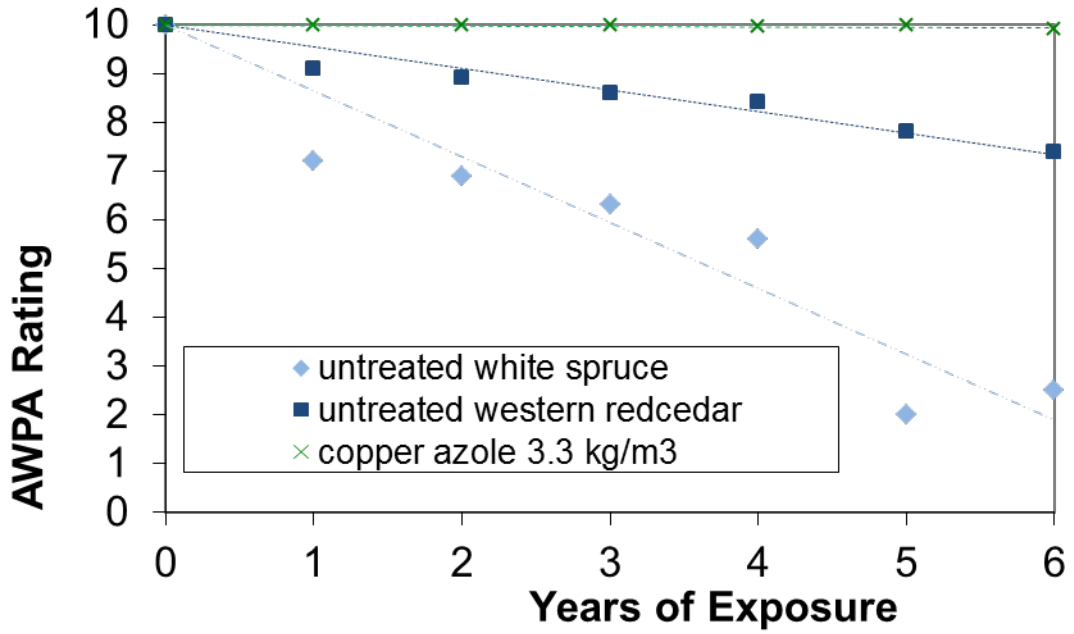

Figure 12 Performance of untreated western redcedar and spruce compared to CA-treated spruce

3.3 Decking

3.3.1 Untreated decks

Very little decay was found on the untreated control decks at Maple Ridge with just one Pacific silver fir board rated 9, one white spruce board rated 9, and one jack pine board rated 9.5. Decay was more advanced at Petawawa with mean ratings from 9.5 to 9.7 for the three species (Table 6).

The slightly greater attack at Petawawa may be attributable to the unusually wet summers at that

site in the last two years, coupled with unusually dry summers at Maple Ridge. More specific SI (Scheffer Index) values were calculated for the exposure period October 2004 to September 2009. There were some missing data from the data files provided by Environment Canada and therefore for these months the most recent climate normal data were used. The resulting values were 58 for Petawawa and 57 for Maple Ridge (Morris and Wang 2011).

3.3.2 CA-B-treated decks

Unincised decks with retentions just below and just above that specified for above-ground residential treated wood in CSA O80 Series-08, 0.9 kg/m^3 (gauge), had mean ratings of 10 for all three species at both sites. Similarly, incised decks with retentions around that specified for above-ground industrial treated wood in CSA O80 Series-08, 1.7 kg/m3 (assay in a 13 mm assay zone), had ratings of 10 for all three species at both sites. No confirmed decay was found in CA-B treated boards, though several boards were rated 9.5 for a suspicion of attack.

Table 6 Retention in CA-B-treated boards and mean five-year decay rating

Species	Target	Incised or Unincised	Solution Strength (%)	Retention (kg/m³) as copper metal			Penetration	Mean 5-year decay ratings	
				By gauge	By assay				
					10 mm	16 mm[1]	%≥5mm	Maple Ridge	Petawawa
Jack pine	None	Unincised	-	-	-	-	-	10.0 (0.1)[2]	9.5 (0.8)
Jack pine	Low	Unincised	0.18	0.27	-	-	-	10.0 (0.0)	10.0 (0.0)
Jack pine	Medium	Unincised	0.39	0.67	-	-	-	10.0 (0.0)	10.0 (0.0)
Jack pine	High	Unincised	0.64	0.90	-	-	-	10.0 (0.0)	10.0 (0.0)
Jack pine	Low	Incised	0.23	-	1.23	0.78	75	10.0 (0.0)	10.0 (0.0)
Jack pine	Medium	Incised	0.45	-	1.85	1.66	78	10.0 (0.0)	10.0 (0.0)
Jack pine	High	Incised	0.61	-	2.42	1.80	90	10.0 (0.1)	10.0 (0.0)
Pacific silver fir	None	Unincised	-	-	-	-	-	10.0 (0.0)	9.6 (0.7)
Pacific silver fir	Low	Unincised	0.12	0.38	-	-	-	10.0 (0.1)	10.0 (0.0)
Pacific silver fir	Medium	Unincised	0.20	0.73	-	-	-	10.0 (0.0)	10.0 (0.0)
Pacific silver fir	High	Unincised	0.26	0.97	-	-	-	10.0 (0.0)	10.0 (0.0)
Pacific silver fir	Low	Incised	0.20	-	1.22	0.96	100	10.0 (0.0)	10.0 (0.0)
Pacific silver fir	Medium	Incised	0.27	-	1.47	1.27	100	10.0 (0.0)	10.0 (0.0)
Pacific silver fir	High	Incised	0.37	-	1.98	1.42	98	10.0 (0.0)	10.0 (0.0)
White spruce	None	Unincised	-	-	-	-	-	10.0 (0.2)	9.7 (0.6)
White spruce	Low	Unincised	0.21	0.15	-	-	-	10.0 (0.0)	9.9 (0.2)
White spruce	Medium	Unincised	0.64	0.43	-	-	-	10.0 (0.0)	10.0 (0.0)
White spruce	High	Unincised	1.14	0.82	-	-	-	10.0 (0.0)	10.0 (0.0)
White spruce	Low	Incised	0.21	-	0.76	0.50	88	10.0 (0.0)	10.0 (0.0)
White spruce	Medium	Incised	0.42	-	1.09	0.63	70	10.0 (0.0)	10.0 (0.0)
White spruce	High	Incised	1.34	-	3.57	2.03	78	10.0 (0.0)	10.0 (0.0)

[1] Depth of analysis sample; [2] Standard deviations given in parentheses

3.3.3 ACQ-D-treated decks

Unincised decks with retentions just below that specified for above ground residential treated wood in CSA O80 Series-08, 2.0 kg/m^3 (gauge), had ratings of 10 for both species at both sites. Similarly, incised decks with retentions around that specified for above ground industrial treated wood in CSA O80 Series-08, 4.0 kg/m3 (in a 13mm assay zone), had ratings of 10 for both

species at both sites. No decay was detected in any ACQ-treated decks at Maple Ridge. At Petawawa, one Pacific silver fir board treated to the medium retention was rated 9.5 for a suspicion of decay, and two white spruce boards at the low retention were rated 8 for moderate decay due to the presence of fruitbodies of wood-rotting fungi.

Table 7 Retention in ACQ-D-treated boards and mean five-year decay ratings

Species	Target	Incised or Unincised	Solution Strength (%)	Retention (kg/m³) of ACQ-D			Penetration	Mean 5-year decay ratings	
				By gauge	By assay				
					10 mm	16 mm[1]	%≥5mm	Maple Ridge	Petawawa
Pacific silver fir	None	Unincised	-	-	-	-	-	10.0 (0.0)[2]	9.6 (0.7)
Pacific silver fir	Low	Unincised	0.26	0.90	-	-	-	10.0 (0.0)	10.0 (0.0)
Pacific silver fir	Medium	Unincised	0.34	1.19	-	-	-	10.0 (0.0)	10.0 (0.1)
Pacific silver fir	High	Unincised	0.46	1.90	-	-	-	10.0 (0.0)	10.0 (0.0)
Pacific silver fir	Low	Incised	0.46	-	2.69	2.55	100	10.0 (0.0)	10.0 (0.0)
Pacific silver fir	Medium	Incised	0.62	-	3.60	2.96	100	10.0 (0.0)	10.0 (0.0)
Pacific silver fir	High	Incised	0.96	-	5.14	4.38	100	10.0 (0.0)	10.0 (0.0)
White spruce	None	Unincised	-	-	-	-	-	10.0 (0.2)	9.7 (0.6)
White spruce	Low	Unincised	0.42	0.40	-	-	-	10.0 (0.0)	9.8 (0.6)
White spruce	Medium	Unincised	1.09	0.88	-	-	-	10.0 (0.0)	10.0 (0.0)
White spruce	High	Unincised	2.04	1.67	-	-	-	10.0 (0.0)	10.0 (0.0)
White spruce	Low	Incised	0.42	-	1.45	0.85	70	10.0 (0.0)	10.0 (0.0)
White spruce	Medium	Incised	1.09	-	4.06	3.00	88	10.0 (0.0)	10.0 (0.0)
White spruce	High	Incised	2.04	-	7.11	4.53	95	10.0 (0.0)	10.0 (0.0)

[1] Depth of analysis core; [2] Standard deviation given in parentheses

4. Conclusions

- CA- and ACQ-treated Pacific silver fir and spruce and CA-treated jack pine stakes meeting CSA O80 for ground contact are performing very well after 6 years.
- Treated spruce meeting CSA O80 is performing better than untreated western redcedar.
- Unincised CA- and ACQ-treated Pacific silver fir and spruce and CA-treated jack pine decks meeting CSA O80 Series-08 residential standards for above ground were completely sound after 5 years.
- Incised CA and ACQ-treated Pacific silver fir and spruce and CA-treated jack pine decks meeting CSA O80 Series-08 industrial standards for above ground were completely sound after 5 years.

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