Final Report

Performance of Selected Wood-Protection-Coated Lumber Products in Hilo, Hawaii

by

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Introduction

While protecting wood with biocides is a widely used and generally accepted method for extending the useful life of a wood product, some users have sought non-toxic systems for wood protection. A variety of methods have emerged that claim to protect wood without biocides or that use less toxic preservatives such as boron. While these products are sold commercially, there is little publicly available comparative data on their performance.

Among the products that appeared nearly a decade ago were BluWood, TimberSil and EcoRed Shield. All of these products – and similar coatings that have emerged under different brand names in recent years – have claimed wood protection performance in above ground exposures subjected to periodic wetting, or Use Category 3B according to the American Wood Protection Association Use Category Standards. Wood applications in this category include decking, railings, millwork, fence pickets and deck joists. All of these applications are exposed to period wetting that creates a higher risk of decay and insect attack.

Developing data on the performance of these materials in relation to both non-treated wood and wood pressure treated with a conventional preservative for the same application would help consumers make informed choices about materials for above ground, exterior exposures.

The goal of this project was to evaluate the performance of wood products coated with various materials and exposed at sites in Corvallis, Ore. and Hilo, Hawaii. This report summarizes the final inspection of the samples in Hawaii after 108 months, or nine years of exposure. This test is now concluded.

Materials and Methods

The materials, species and number of samples in each exposure set are detailed in Table 1. All materials in this test were commercially treated and provided to OSU as nominal 2x4 lumber that was then cut to lengths appropriate for each test method. Unexposed samples were retained for later examination. There are two sets of samples placed at the test sites. The first sets were exposed in November 2013 (Table 1). In June 2015, additional samples were placed consisting of new, non-treated Douglas-fir lumber, the new EcoRed Shield (II), and HiBor borate treated wood in decay and termite Ground Proximity tests as well as the Above Ground AWPA E34 Sandwich trials.

The lumber was cut to the appropriate size for each exposure and then all of the cut ends were dipped for 30 seconds in a solution of 4.8% pentachlorophenol in diesel oil for the first set or 2% copper naphthenate (as Cu) in diesel oil for the second set to

protect the potentially untreated ends exposed by cutting. This was essential since most of the tested treatments function as barriers and the penta and copper naphthenate create a secondary barrier on the end cuts that should protect the wood from fungal and termite invasion through these exposed areas.

Ground Proximity Termite Test

Samples were exposed in test sites at Hilo, Hawaii or Corvallis, Ore. The Hilo site receives over 200 inches of rainfall per year and has average daytime temperatures between 80 degrees and 85 degrees F, while the Corvallis site receives approximately 45 inches of rainfall per year and has daytime temperatures that range from 40 degrees to 80 degrees F, depending on the time of year. The risk of decay at the Hilo site is described as extreme, while that at Corvallis is considered moderate.

Table 1. *Treatments evaluated for decay and termite resistance in above ground exposures at sites located in Corvallis, Oregon or Hilo, Hawaii.*

Treatment	*Wood Species*	*Number of Samples Exposed/Site*		
		E18 Termite GP	*E26 Decay GP*	*Sandwich test*
None	Douglas-fir	15	35	10
TimberSil	Southern pine	15	35	10
EcoRed Shield I	Douglas-fir	15	35	10
BluWood	Douglas-fir	15	35	10
Copper Azole	Douglas-fir	15	35	10
EcoRed Shield II*	Hem-Fir	10	10	10
HiBor*	Douglas-fir	10	10	10

** Added to test sites, June 2015*

The materials were tested in three configurations. Resistance to attack by Formosan termites was evaluated using a modification of AWPA Standard E26. Briefly, hollow concrete blocks were placed on the soil. Pine sapwood stakes were driven into the ground within the hollow blocks to attract termites, then the wood test blocks (nominal 2x4 by 4 inches long) were placed on the concrete blocks in between non-treated wood that serves as a feeder material for the workers to explore (Figure 1).

The blocks were then covered with a water shedding cap that produced a dry, non-soil contact exposure equivalent to a Use Category 1 or 2 exposure. It is important to note that this test does not expose the wood to any rainfall and, as a result, there is no potential for leaching of any active ingredients from the blocks.

Formosan termites are extremely aggressive and untreated wood at the Hilo test site is typically destroyed within six months of installation. The control and test samples were

evaluated at six-month intervals for degree of termite attack on a scale from 10 (no attack) to 0 (failure).

Fifteen blocks were tested for each treatment and the test was evaluated after 7, 12, 18 or 30 months of exposure. The 10 samples in the second set was evaluated at the same intervals.

Ground Proximity Decay Tests

Resistance to decay in a UC 3B-type exposure was evaluated in two above ground tests. In the first, 5-inch long blocks were cut and placed on concrete blocks following the procedures described in AWPA Standard E18.

Thirty-five blocks were installed for each treatment. Block condition was visually assessed on a scale from 10 (sound, no decay) to 0 (completely decayed).

Samples of each treatment were also evaluated in a Sandwich test. Briefly, a total of 30 samples, 11 inches long, were cut from the boards in each treatment. Three pieces from a given treatment were combined and tied together using plastic zip-ties.

The assemblies were then exposed on aluminum racks approximately 12 inches off the ground. These assemblies are designed to trap water and encourage fungal colonization between the board faces. Test assemblies in this procedure sometimes use a non-treated sample in the middle to serve as a decay susceptible feeder for decay fungi to grow before they attack the treated test pieces on the outside. However, this was not done in this test and instead, all three pieces were composed of the same treatment.

These assemblies were visually assessed for degree of decay by removing the zip-ties and assessing the surface condition of each piece on a scale from 10 (no decay) to 0 (complete failure). Decayed or suspicious areas were further probed with a sharp-edged tool to determine the extent of any damage. The sandwiches were reassembled and placed back on the racks for additional exposure. A total of 10 sandwiches were exposed per treatment.

Samples were set out at the field site in two tranches, the first set placed in the field in 2013 was assessed for a total of 108 months. The second set placed in the field in 2015 was assessed for a total of 90 months.

Results and Discussion

Ground Proximity Termite Test

Termites had completely destroyed all of the feeder material placed around the test specimens after 7, 12 and 18 months of exposure (Table 2). This indicated that

conditions were suitable for aggressive termite attack over the entire test period. In addition, the covers had kept the specimens dry, meaning the exposure approximated a UC 2 or UC 3A exposure.

The 24-month inspection indicated that little termite attack had occurred over the intervening six months of exposure. While there had been some attack of feeder material on two of the three arrays, it was insufficient to warrant an inspection. It is unclear why termite attack declined in this period; however, others using the test site have noticed a recent decline in attack levels. Additional feeder material was placed around the arrays to help boost termite attack.

The 30-month inspection revealed termite attack in material from the first test. These samples were removed, rated for a final time and discarded. The feeder materials in the array containing the newer samples were attacked but not to the extent that would indicate severe termite pressure on the test materials.

The samples set out in June 2015 were evaluated after 18 months of exposure (Table 3). HiBor treated samples had only slight evidence of termite attack, while both the EcoRed Shield II and untreated controls had slightly higher degrees of damage (lower ratings). All of the attack, however, was light compared to the previous test and the test was not evaluated at 24 months.

A substantial amount of untreated wood was buried around the site to reinvigorate the colony. There was no evidence that the colony was active after 2018 and this part of the trial was discontinued.

Table 2. *Condition of blocks treated with various preservative systems and exposed to Formosan termite attack for 7, 12, 18 or 30 months in Hilo, Hawaii using an AWPA E26 Ground Proximity termite test.*[a]

	Sample Condition			
Treatment	*7 months*	*12 months*	*18 months*	*30 months*
Untreated	5.53 (2.80)	1.3 (3.3)	3.1 (3.3)[b]	3.2 (3.2)
EcoRed Shield I	0.27 (1.03)	0	0	0
BluWood	4.00 (3.20)	0.6 (2.3)	1.8 (2.4)	1.8 (2.0)
Timbersil	8.40 (2.02)	8.0 (3.3)	9.0 (1.1)	8.5 (1.8)
Copper Azole	9.77 (0.37)	9.9 (0.3)	9.7 (0.8)	9.9 (0.3)

[a]Values represent means of 15 specimens per treatment. Figures in parentheses represent one standard deviation.
[b]New untreated control samples were installed at 12 months to confirm that termite attack was continuing.

Figure 2. *Example of a termite array with samples treated with EcoRed Shield II, HiBor or left untreated in the E26 Ground Proximity termite test after installation in June 2015.*

Table 3. *Condition of blocks treated with various preservative systems and exposed to Formosan termite attack for 18 months in Hilo, Hawaii using an AWPA E26 Ground Proximity termite test.*[a]	
Treatment	*Sample Condition*
Control	9.60 (0.97)
EcoRed Shield II	9.22 (1.09)
HiBor	9.91 (0.20)
[a]Values represent means of 15 specimens per treatment. Figures in parentheses represent one standard deviation.	

Ground Proximity Decay Tests

Samples exposed in the Ground Proximity test were heavily colonized by dark pigmented fungi shortly after installation, but showed no signs of fungal degradation for the first 30 months of exposure (Figures 3, 4). Untreated Douglas-fir heartwood controls had average ratings of 9.75 and 9.62 with only spots of decay on the edges of the samples after 24 and 30 months of exposure, respectively (Table 4, Figure 8). The untreated controls continued to deteriorate after 37 months of exposure and experienced more substantial decay 42 months after installation.

The downward trend in ratings continued over the next 30 months of exposure and ratings for the controls averaged 4.4 after a total of 72 months (Figure 8). Douglas-fir heartwood is moderately durable to decay in above ground exposures and the performance in this test is consistent with that property. After 108 months, all untreated controls in the first batch had failed and all but one control had failed in the second batch after 90 months.

The EcoRed Shield I samples began to experience decay on the lower surfaces within 30 months of installation (Figures 5 and 8) and the levels of decay were similar to those for the non-treated controls. After 30 months, the EcoRed Shield I samples followed a trend similar to the untreated controls, although the ratings were somewhat lower than untreated wood from 48 months of exposure onwards. After 108 months, all replicate samples except for one had failed. The results indicate that EcoRed Shield I provided little to no added protection against fungal attack in this exposure.

BluWood samples also followed trends similar to those for the untreated controls, with some decay evident 30 months after installation (Figure 6). The decay levels continued to increase with time and BluWood samples were only slightly different from the controls 72 months after installation. After 108 months, all BluWood samples had failed. The results suggest that BluWood provided little additional protection to timber under these exposure conditions.

Timbersil-treated samples followed similar trends to those for the untreated controls, as well as the EcoRed Shield I and BluWood samples for the first 42 months of exposure. However, decay ratings declined precipitously from 48 months onward and by 72 months, all but two replicate samples had failed. After 108 months, all samples had failed. The Timbersil-treated samples were noted for the extreme hygroscopicity over the course of the exposure and, eventually, the samples began to fall apart due to the combination of decay and defibrillation of the timber.

Copper azole-treated samples experienced little evidence of decay for the first 58 months, although some samples had slight evidence of decay, especially around knots or other defects. Decay was noted at the ends of some samples 72 months after installation likely due to exposure of a cut surface (Figure 9). After 108 months, average ratings had declined further to about 4 and several samples had failed at the exposed end grain.

It is important to note this decay was developing on the cut exposed ends of the timber where the initial treatment was absent. While the cut ends of each sample were briefly dipped in pentachlorophenol prior to exposure, this treatment was likely to penetrate only a short distance into the wood.

Thus, the presence of decay in the cut ends is consistent with the limited ability of end-cut treatments to retard decay under high decay hazard conditions. This in no way suggests that surface treatments of cuts exposed on treated wood not be treated, but it indicates that there is a limit to the protective effects of these shallow treatments. However, after the duration of this test, copper azole treated wood still far outperformed other treatments in this test, despite early failures caused by cutting and end treating.

Table 4. *Condition of various wood samples exposed to fungal attack in an AWPA E18 Ground Proximity test for 18 to 108 months in Hilo, Hawaii.*

	Average Condition[a]								
Treatment	*18 months*	*24 months*	*30 months*	*37 months*	*42 months*	*48 months*	*58 Months*	*72 Months*	*108 Months*
Control	9.90 (0.20)	9.84 (0.32)	9.62 (0.60)	8.89 (1.10)	7.89 (1.01)	8.50 (1.65)	6.74 (1.55)	4.60 (2.43)	0 (0)
EcoRed Shield I	9.86 (0.20)	9.61 (0.58)	9.54 (0.44)	9.00 (1.36)	7.98 (1.70)	7.25 (1.61)	6.00 (2.61)	3.72 (2.79)	0.03 (0.18)
BluWood	9.90 (0.20)	9.77 (0.35)	9.50 (0.89)	8.90 (1.14)	8.24 (1.09)	7.71 (1.69)	6.45 (1.75)	5.03 (2.06)	0 (0)
Timbersil	9.90 (0.20)	9.53 (0.76)	9.42 (0.40)	8.58 (1.28)	7.73 (1.41)	2.65 (2.48)	1.65 (2.17)	0 (0)	0 (0)
Copper Azole	9.98 (0.08)	10.00 (0)	10.00 (0)	10.00 (0)	9.92 (0.23)	9.94 (0.25)	9.77 (.0.43)	8.87 (1.50)	4.07 (3.04)

[a]Samples were visually assessed on a scale from 10 (no damage) to 0 (complete failure). Values represent Average ratings for each timepoint, while figures in parentheses represent one standard deviation.

Figure 3. *Example of an E18 Ground proximity decay test prior to the 18-month assessment.*

Figure 4. *Example of an E18 Ground proximity decay test prior to the 24-month assessment for samples on the right and 6-month assessment for samples on the left. Note extensive microbial growth on the older samples.*

Figure 5. *Examples of a non-treated control (top) showing extensive surface growth and slight decay and an EcoRed Shield I sample showing white fungal growth and decay.*

Figure 6. *BluWood ground proximity sample after 24 months of exposure showing decay pockets with concentration of the original blue dye used to color the wood.*

Figure 7*. Examples of EcoRed Shield I (middle) and Copper Azole (left and right) ground proximity samples after 108 months of exposure. The EcoRed Shield I sample pictured was the only remaining sample at this timepoint that had not failed.*

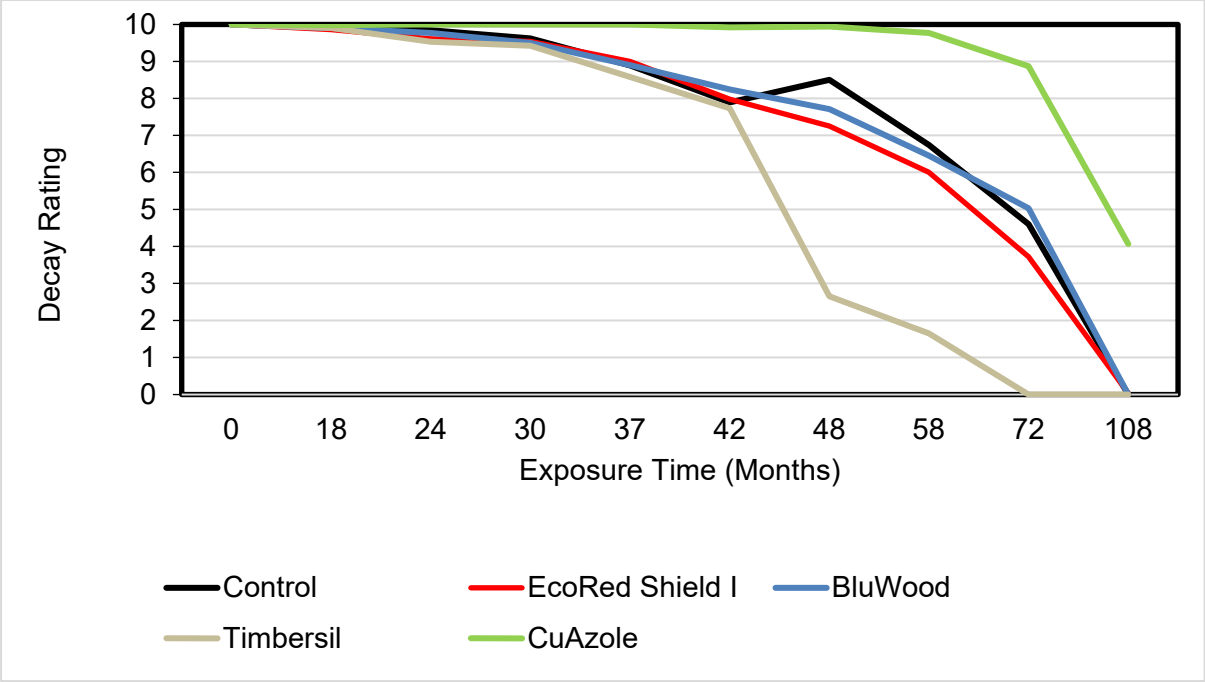

Figure 8. *Condition of untreated, EcoRed Shield I, BlueWood, Timbersil and copper azole-treated samples exposed for 108 months in a ground proximity test.*

Figure 9. *Example of a copper azole-treated ground proximity specimen showing a sound exterior but decay in the cut, exposed end grain. This effect was seen from 72 months onward.*

Controls set out with the second tranche of test samples performed similarly to the controls in the first tranche (Table 5 and Figure 10). EcoRed Shield II samples have also followed trends similar the controls, again suggesting that the EcoRed Shield provided little to no added protection to the wood.

HiBor treated samples were not included in the first test, but have performed similarly to the untreated controls through the duration of this test. HiBor treatment is restricted to use in above ground exposures with protection from continuous wetting. The Ground Proximity test poses an extreme wetting challenge that is outside the recommended application for this material and the results illustrate why HiBor treatment should not be used in exterior exposures.

Table 5. *Condition of various wood samples exposed to fungal attack in an AWPA E18 Ground Proximity test for 90 months in Hilo, Hawaii.*						
	Sample Condition					
Treatment	*18 months*	*24 months*	*30 months*	*40 months*	*54 months*	*90 months*
Control	9.98 (0.11)	9.57 (0.41)	9.68 (0.95)	8.47 (1.68)	6.50 (2.09)	0.05 (0.22)
EcoRed Shield II	9.95 (0.16)	9.50 (0.40)	8.95 (1.36)	8.05 (1.50)	5.70 (2.30)	0.30 (1.34)
HiBor	10.00 (0.00)	9.63 (0.36)	8.90 (1.92)	7.95 (2.09)	5.55 (3.50)	0 (0)
[a]Samples were visually assessed on a scale from 10 (no damage) to 0 (complete failure). Values represent means of 10 samples, while figures in parentheses represent one standard deviation.						

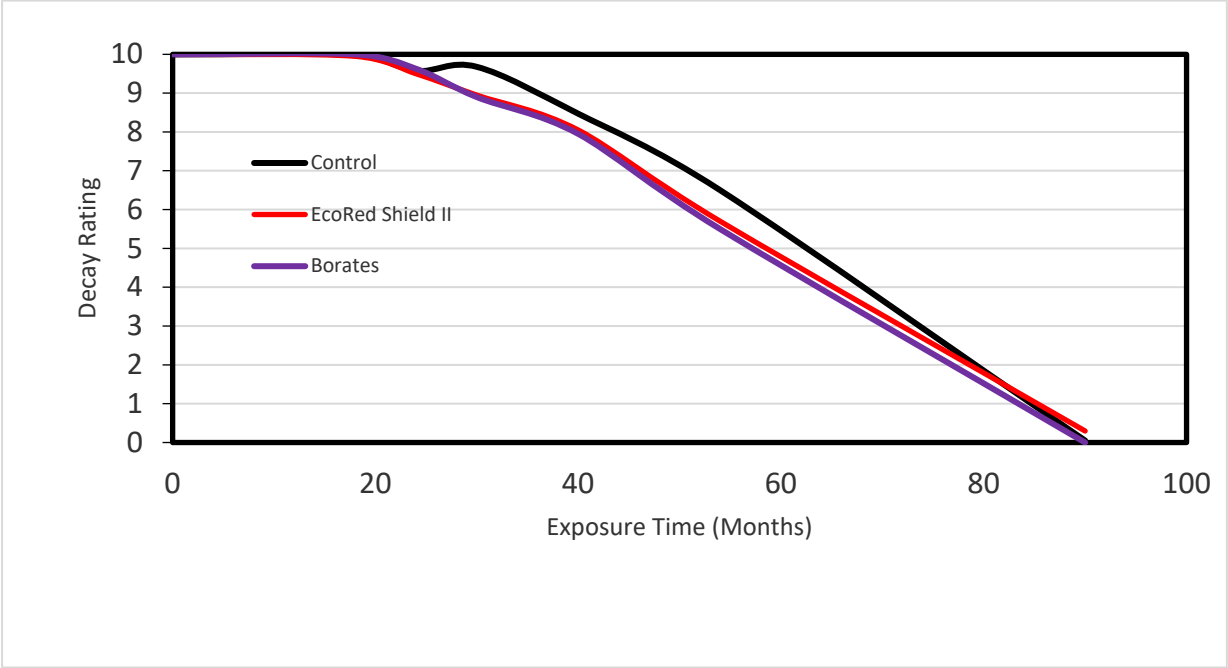

Figure 10. *Decay ratings of untreated controls, EcoRed Shield II, and HiBor treated samples over a 90-month exposure.*

Above Ground Sandwich Test

As was the case with the ground proximity tests, samples were set out in two tranches, one in 2013 and one in 2015. The sandwiches set out in 2013 were disassembled after 18, 24, 30, 37, 42, 48, 58, 72 and 108 months of exposure (Table 6). The sandwiches set out in 2015 were assessed after 18, 24, 30, 40, 54 and 90 months of exposure. The sandwich samples were UV degraded on the upper surfaces, but there was no evidence of fungal attack on any of the samples after 7 or 12 months

Untreated Douglas-fir samples in the first tranche had average ratings of 9.9 after 18 months, as did the BluWood and Timbersil treated samples. As with the Ground Proximity decay tests, the Timbersil samples were water-logged and fibers were flaking off the upper, ultraviolet light exposed surfaces. The copper azole-treated samples had no evidence of decay and had an average rating of 10.

Untreated samples began to show more significant evidence of decay 42 months after treatment, but the samples were still largely sound after 48 months of exposure. Decay developed more rapidly after an additional 10 months of exposure (58 months total), and the average sample rating was just over 2.5 points lower than the previous sampling. Interestingly, another 14 months of exposure (72 months total), did not cause much change in sample ratings from the 58-month time point, but after 108 months, most of the untreated samples were destroyed.

EcoRed Shield I samples experienced a gradual decline in condition over the exposure period with ratings that were generally lower (more decayed) than those for the untreated controls. In some instances, individual elements of a sandwich were close to failure after only a short time in test (Figure 9). All samples had failed the 108-month assessment (Figure 10). As with the Ground Proximity test, the results suggest that EcoRed Shield I provided little to no additional wood protection.

BluWood samples again performed similarly to the untreated controls, suggesting that the treatment provided little added protection under this exposure regime. About half of the samples had failed by the 108-month assessment and the remainder had ratings ranging from 1 to 4.

Timbersil samples followed a trend similar to that observed in the Ground Proximity test, with a gradual decline in protection over the first 37 months but then a steep decline from that point onwards. As with the Ground Proximity test, the samples were highly hygroscopic. This property might cause concerns in an exterior exposure because the material weights might begin to affect designs. All samples had failed by the 108-month assessment. Timbersil samples were in very poor condition after 72 months and many were close to failure. These results again indicate that Timbersil provided no added protection against fungal attack under these exposure conditions.

Copper azole treated samples outperformed all other treatments in the test and maintained minimal damage through 72 months of exposure. The condition of copper azole treated samples began to decline more rapidly at the last assessment at 108 months where ratings averaged 6.85. However, this was still far above all other treatments in the study. Similar issues with decay originating at the cut ends of specimens was observed, although these developed later than in the ground proximity test.

Sandwiches exposed in 2015 had slight evidence of decay after 18 months of exposure and decay ratings continued to decline after 30 months (Table 7). Decay ratings also declined on EcoRed Shield II samples at rates that were similar to those for the EcoRed Shield I. EcoRed Shield II and control samples had similar ratings at 54 months, suggesting the treatment provided little added protection. After 90 months, nearly all of the EcoRed Shield II samples had failed.

HiBor treated samples exhibited little evidence of decay for the first 30 months of exposure, but then decay became evident on some samples. While HiBor treated samples were beginning to decay, the samples were still in relatively good condition 54 months after installation. At the 90-month assessment, borate-treated samples had taken a dramatic turn for the worse and the majority of the samples had failed.

HiBor is not recommended for uses subjected to continuous wetting, while EcoRed literature implied some applications for this exposure. The HiBor results in the Sandwich test suggest this treatment provided only marginal improvements in protection in an exterior environment compared to the control. Ground Proximity results clearly show that the treatment provides far less protection when it is subjected to severe leaching conditions. The EcoRed Shield and BluWood treated samples provided no evidence of wood protection in either test compared to the untreated controls.

Figure 9. *Example of an EcoRed Shield I sandwich with extensive decay on the outer sample after 30 months of exposure. Interestingly, this sample remained in service through 72 months despite this early decay damage.*

Figure 10: *Example of sandwich test sample condition after 108 months of exposure. An EcoRed I sample is completely degraded and can be penetrated with a screwdriver, whereas a copper azole-treated sample at the bottom of the photo is in much better condition.*

Table 6. *Condition of various wood samples exposed for 18 to 108 months as sandwiches in an above ground test in Hilo, HI*

Treatment	*Average Condition*								
	18 months	*24 months*	*30 months*	*37 months*	*42 months*	*48 months*	*58 months*	*72 months*	*108 months*
Control	9.90 (0.23)	9.75 (0.42)	9.40 (1.30)	9.60 (0.90)	8.65 (2.04)	8.50 (1.74)	5.93 (2.67)	5.87 (3.06)	1.43 (2.02)
EcoRed Shield I	9.47 (0.27)	9.02 (0.72)	8.90 (0.98)	8.60 (1.03)	7.57 (1.64)	7.07 (2.04)	5.60 (1.99)	3.73 (2.68)	0 (0)
BluWood	9.90 (0.18)	9.89 (0.27)	9.90 (0.18)	9.80 (0.20)	9.43 (0.65)	9.40 (0.40)	8.67 (1.08)	6.49 (2.11)	1.50 (1.79)
Timbersil	9.90 (0.18)	9.83 (0.33)	9.40 (0.57)	9.50 (0.40)	7.57 (1.50)	7.67 (0.93)	6.30 (1.43)	2.20 (3.29)	0 (0)
Copper Azole	10.00 (0.0)	10.00 (0.0)	10.00 (0.0)	10.00 (0.0)	9.93 (0.21)	10.00 (0.00)	10.00 (0.00)	9.56 (1.08)	6.85 (3.02)

[a]Samples were visually assessed on a scale from 10 (no damage) to 0 (complete failure). Values represent average ratings at each timepoint, while figures in parentheses represent one standard deviation.

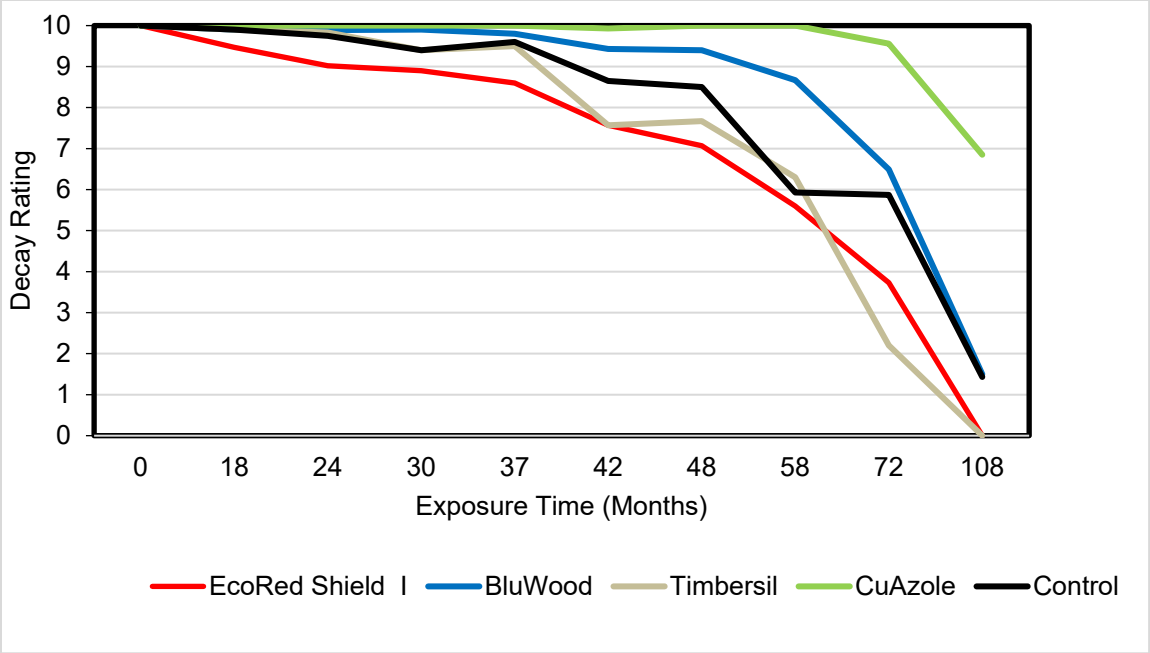

Figure 10. *Average Decay ratings for untreated, EcoRed Shield I, BluWood, Timbersil and copper azole-treated samples exposed for 108 months in a sandwich test.*

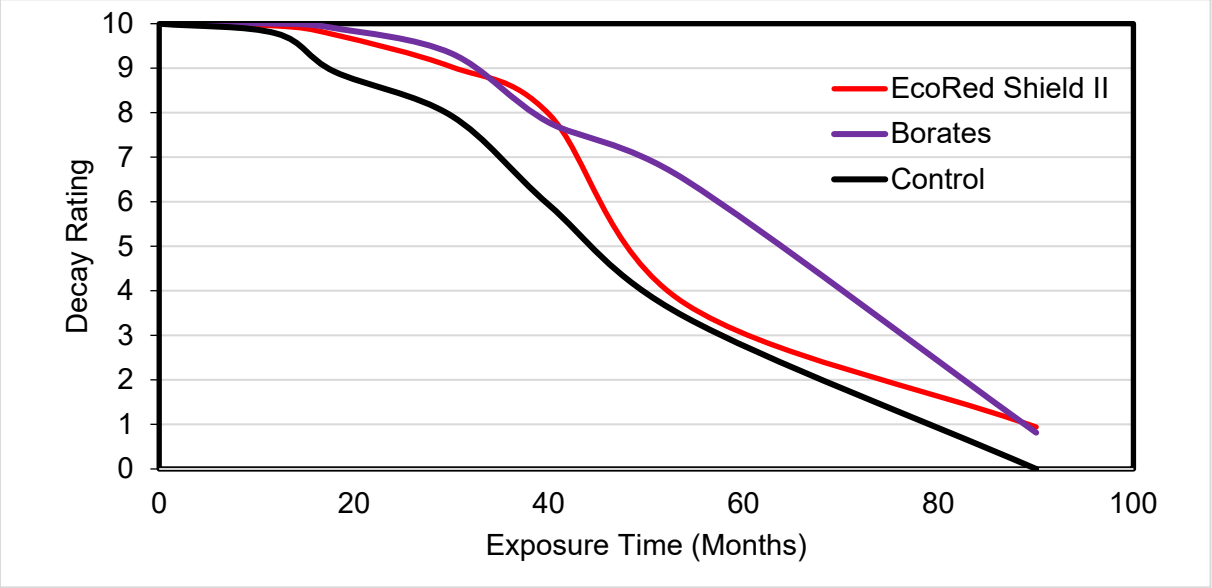

Figure 11. *Decay ratings for untreated, EcoRed Shield II and Hi-Bor samples exposed for 90 months in a sandwich test.*

Table 7. *Condition of various wood samples exposed for 18 to 90 months as sandwiches in an above ground test in Hilo, HI*						
	Sample Condition					
Treatment	*12 months*	*18 months*	*30 months*	*40 months*	*54 months*	*90 Months*
Control	9.78 (0.55)	8.92 (1.64)	7.93 (1.98)	5.93 (2.67)	3.41 (3.19)	0 (0)
EcoRed Shield II	9.95 (0.11)	9.75 (0.31)	9.03 (1.17)	7.97 (1.57)	3.71 (3.63)	0.94 (2.13)
HiBor	10.00 (0.00)	9.90 (0.15)	9.33 (0.80)	7.78 (1.82)	6.49 (2.14)	0.81 (1.57)
[a]Samples were visually assessed on a scale from 10 (no damage) to 0 (complete failure). Values represent average ratings at each assessment, while figures in parentheses represent one standard deviation.						

Conclusions

Termite trials showed that only copper azole was effective against Formosan termite attack (HiBor was not tested). Ground proximity and sandwich trials provided slightly different trends, but both showed that EcoRed Shield, BluWood and Timbersil provided little to no added protection against fungal attack compared to untreated controls.

Copper azole performed well in both tests although some decay developed on the cut surfaces. The results illustrate the difficulty of protecting timber in a high decay hazard environment and the need for pressure treatments, especially in these environments.

References

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