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Above-Ground Termite Resistance of Naturally Durable Species in Ontario and Mississippi

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Above-Ground Termite Resistance of Naturally Durable Species in Ontario and Mississippi

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ABSTRACT

A collaborative above-ground protected termite field test was initiated by FPInnovations and the USDA Forest Service at sites in Ontario and Mississippi. The aims of the experiment were to compare the rate of attack in protected, above-ground exposures by the subterranean termite species, *Reticulitermes flavipes*, between northern (Ontario) and southern (Mississippi) test sites and to generate performance data to understand the resistance to termites of selected naturally durable North American species. After 5-years of exposure, termite attack was greater in untreated pine sapwood controls in Mississippi than Ontario, though similar in the naturally durable species and the MCA-treated reference. All naturally durable heartwoods evaluated were more resistant to termites than untreated controls, and less resistant than the MCA-treated reference. More time is needed to define the service life expectations of naturally durable heartwood species and to determine whether there are differences in their termite resistance.

Keywords: field testing; natural durability; North America; *Reticulitermes flavipes,* termites

1. INTRODUCTION

The Eastern subterranean termite (*Reticulitermes flavipes* Kollar) is widely distributed in the contiguous United States and extending north into some areas of southern Canada (Lebow and Highley 2006). Its expansion is limited by cold temperatures with 50% of individuals unable to survive a 1 h exposure to -5.1°C (Clarke *et al*. 2013). Within its range, termite pressure varies with greater termite hazard occurring in southern regions. However, the impact of climate on an active colony's ability to consume non-preferred woods is less well understood. With climate change creating opportunities for termites to extend their range in some areas (Ahmed *et al.* 2011; Buczkowski and Bertelsmeier 2017), it's critical to understand the threat these pests pose to the built environment in these marginal habitats.

To address the aforementioned needs and to evaluate the performance of wood protection technologies under Canadian conditions, FPInnovations set up a new termite test site in Kincardine, Ontario in 2016. This area is close to the northerly known limit of the Eastern subterranean termite, *R. flavipes*, in North America. To accurately interpret data generated at the site, there is a need to understand the magnitude of the termite pressure, ideally relative to a more established termite field test site. The USDA Forest Service's Harrison Experimental Forest in Saucier, Mississippi has a well-recognized termite hazard that has been used as a termite test site for over 60 years. The present work develops matched performance data for comparing performance of wood products at these sites. This will facilitate the use of data from northern sites to estimate performance in southern exposures, and vice versa.

Recent research on the field performance of naturally durable species has defined their performance in ground contact and above-ground against decay organisms (Morris *et al.* 2011; Morris *et al.*2016; Kirker *et al.* 2018). The impact of extractives from naturally durable species has also been evaluated in a series of experiments (Hassan et al. 2017; 2019; 2021). However, field performance data on termite efficacy in above-ground protected applications is lacking.

Recent changes to EN 350 (CEN 2016) have classified Alaska yellow cedar (*Callitropsis nootkatensis* D. Don) as "Moderately durable". Alaska yellow cedar has been shown to resist attack by *Coptotermes formosanus* Shirakiin choice and no-choice laboratory tests (Grace and Yamamoto 1994, Morales-Ramos and Rojas 2001, Morales-Ramos *et al.* 2003). Similarly, Arango *et al*. (2006) found that Alaska yellow cedar showed moderate resistance to *R. flavipes* in a no choice test. Field stake tests in Florida also indicated some resistance to attack by *R. flavipes* (Morris *et al.* 2011). However, there are no reports on the resistance of Alaska yellow cedar to *R. flavipes* in protected, above-ground applications. It was hypothesized that resistance may be greater as the extractives associated with termite resistance would be better protected from leaching and biodegradation.

Western redcedar (*Thuja plicata* Donn) has been evaluated in several termite tests and has shown highly variable performance against *R. flavipes* (Carter and Smythe 1974, Morris *et al.* 2009, Kirker *et al.* 2013). Recent work found a correlation between the redness of western redcedar and resistance to *C. formosanus* in a no choice laboratory test (Stirling *et al.* 2015). This suggests that it may be possible to sort for western redcedar with higher termite resistance on the basis of color. The present work will examine this correlation further
in a field test against *R. flavipes*.

There are limited termite-resistance data for northern white cedar (*Thuja occidentalis* L.). It has been shown to have some resistance to *R. flavipes* in an above-ground semi-protected (Behr and Smith 1976) field test compared to southern pine sapwood, and ground contact (Morris *et al.* 2011) field tests in Florida. Flakeboard made from northern white cedar has also shown moderate termite resistance compared to aspen in an above-ground-protected termite test in Florida (Haataja and Laks 1995). The present work examines its resistance to *R. flavipes* in a protected, above-ground application, in comparison to competing naturally durable species, and a preservative-treated reference.

2. MATERIALS AND METHODS

2.1 Sample Preparation and Treatment

Ten nominal 2x4 inch (38 x 89 mm) boards were obtained from the sources indicated in Table 1. From each board, two 18" (0.46 m) stakes and a central ½" (12 mm) reference retained sample for extractives or preservatives analysis were cut. The resulting stakes were labelled "A" and "B". One set was sent to each test site. Color measurements (CIE L*a*b*) were taken from eight points on each naturally durable board using a Konica Minolta CM-700d spectrophotometer. Western redcedar boards were sorted into pale ($6.2 < a^* < 10.8$) and red colored groups ($10.8 < a^* < 14.1$).

The test method is essentially as described in AWPA Standard E21-13 (American Wood Protection Association 2013). Ten boxes were constructed from chromated copper arsenate (CCA)-treated plywood, 600 mm wide x 350 mm high x 1000 mm long with a slanted top to facilitate water runoff and an open bottom. The inside and outside were painted with an alkyd exterior primer and two coats of a pale green (Ontario) or white (Mississippi) topcoat (Figure 1).

Table 1: Test Material.

Group	Common Name and descriptor	Latin Name	Source
1	Western redcedar (pale)	*Thuja plicata* Donn	Sunbury Cedar, Delta, BC
2	Western redcedar (red)	*Thuja plicata* Donn	Sunbury Cedar, Delta, BC
3	Alaska yellow cedar	*Callitropsis nootkatensis* D. Don	Sunbury Cedar, Delta, BC
4	Northern white cedar	*Thuja occidentalis* D. Don	Limaco, Lévis, Quebec
5	Southern pine sapwood (control) (loblolly, shortleaf, longleaf and slash pines)	*Pinus* spp.	Bell's Lumber Starkville, Mississippi
6	Southern pine sapwood commercially treated with MCA to 0.06 pcf (0.96 kg/m^3) (reference)	*Pinus* spp.	Bell's Lumber Starkville, Mississippi

Figure 1: AWPA E21 field test of naturally durable species, Kincardine, Ontario (left) and Harrison Experimental Forest, Mississippi (right).

2.2 Test Sites

2.2.1 Kincardine, Ontario

FPInnovations' termite test site is a residential lot in the center of the Lorne Beach Termite Management Area near Tiverton in the Municipality of Kincardine, Ontario near the present northern limit of the range of *R. flavipes*. The lot is surrounded by trees and has sandy, well-drained soil with a thin layer of leaf litter on top. There is marshland at a lower elevation nearby, indicating a high water table and plentiful supply of soil moisture at depth. The area receives mean annual precipitation of 998 mm, with a low of 70 mm in July and a high of 130 mm in January. It has an average yearly temperature of 6.2°C, with mean daily maximum and minimum temperatures of -2°C and -10°C in January, and 24°C and 13°C in July (as reported by nearby weather station in Owen Sound, Ontario). The climate places it within the zone of medium out-of-ground decay hazard with an updated Scheffer Climate Index of 49 (Morris and Wang 2008). The temperatures are moderated by proximity to Lake Huron and the area is prone to lake-effect snow which provides additional insulation to the soil in winter.

Test boxes were assembled, and samples were installed at the Kincardine site on September 30, 2016. MCA-treated samples were mistakenly omitted at this time; however, their locations were mapped, and feeder stakes installed with the samples added June 22, 2017. None of the feeder stakes for these samples had termite tubes reaching the top at the nine-month inspection, so it is believed the delayed installation has had little impact.

2.2.2 Harrison Experimental Forest, Mississippi

The USDA FPL field test sites are located in forested and cleared areas within the Harrison Experimental Forest (HEF) in Saucier, Mississippi. The HEF has a slope of 5 to 12 percent, soil that is Poarch fine sandy loam with a pH of 4.9, and an average annual precipitation of 1600 mm. Mean annual minimum and maximum temperatures (Jackson data) are 12°C and 24°C, with no mean monthly temperature below 10°C. The updated Scheffer Index value for Jackson is 70 (Morris and Wang 2008). Ground cover is mostly wiregrass, broom sage and yaupon holly. The HEF has a well-documented infestation of Eastern subterranean termites, *R. flavipes*. Certain parts of the HEF also suffer heavy attack from *Fibroporia radiculosa* (Peck) Parmasto.

Samples were installed in a cleared forest area on June 22nd, 2016. The soil for each test house was leveled with a garden hoe. For both AWPA E21 setups at each location, cinder blocks were placed on the smoothed soil in two sets of four blocks for a total of eight blocks per box. Feeder stakes (19mm x 19mm x 152mm) driven into the soil were placed in each cinder block opening and samples were placed directly on top of cinder blocks touching the feeder strips. This was done to mimic the building structure. Feeder strips heavily attacked by termites or decay were replaced at the annual rating time.

2.3 Inspection

Each test specimen was removed from the covering box and examined visually for termite attack and indications of decay such as the presence of fungal mycelium or discoloration. Each specimen was assigned a rating based on the AWPA E21 grading systems for decay and termite attack as shown in Tables 2 and 3. For Ontario, the persons performing the ratings differed for the first three years and fifth year. For Mississippi, the rater was the same person throughout the five-year study period.

Table 2: Decay Rating System.

Decay Rating	Condition	Description
10	Sound	No sign or evidence of decay, wood softening, or discolouration 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.

Table 3: Termite Attack Rating System.

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 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.

3. RESULTS AND DISCUSSION

The accuracy and applicability of the findings should be considered within the limitations of the methods and procedures applied in the project. Results apply only to specimens tested.

Test materials were inspected for degradation by both decay and termites. The AWPA E21 test is intended primarily for evaluating performance against termites but growth of wood-rotting basidiomycetes up through the feeder stakes is often observed. In Ontario, confirmed decay was observed in the untreated control with an average rating of 8.7 after 5-years of exposure (Figure 1). Less decay was observed in the naturally durable species and in the MCA-treated reference with average ratings ranging from 9.6 to 10. Decay was more advanced in the specimens exposed in Mississippi, with the untreated control having an average decay rating of 2.3 after 5- years of exposure (Figure 2). The naturally durable species had average ratings ranging from 6.7 to 7.9, which were indicative of moderate decay. The MCA-treated controls remained sound with an average rating of 10. The relative resistance of these materials is similar to results from exposure in AWPA E25 decking tests under UC3.2 exposure conditions (Morris et al. 2016; Stirling et al. 2017). These data suggest that the AWPA E21 method could be used for evaluating decay resistance under UC2 conditions in addition to termite resistance.

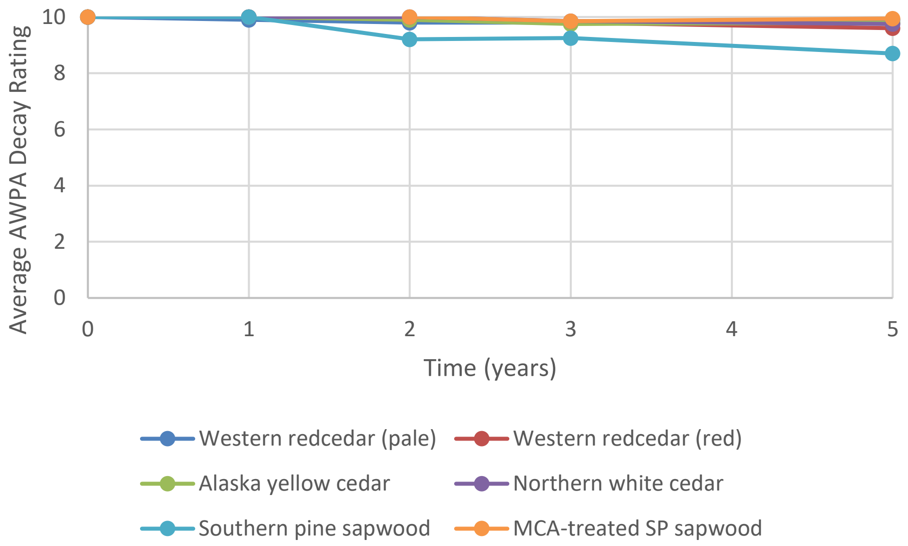

Figure 1: Average Extent of Decay in Test Materials Exposed in Kincardine, Ontario.

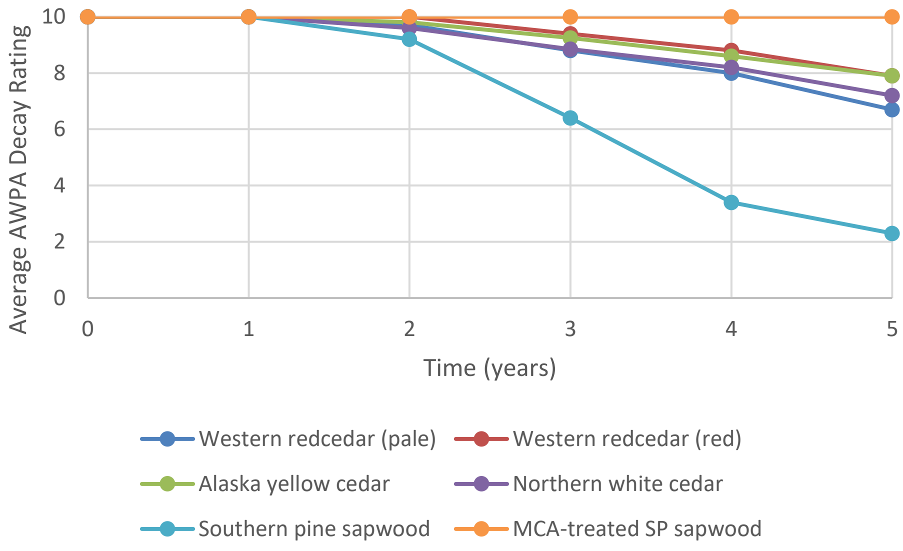

Figure 2: Average Extent of Decay in Test Materials Exposed in Saucier, Mississippi.

Termite attack in Ontario was sporadic with some feeder stakes unaffected by termites. However, every box had some termite attack confirming termites were present and widely distributed. The untreated control was most degraded with an average rating of 7.1 after 5-years of exposure (Figure 3). The naturally durable species were similarly attacked by termites with average ratings rating from 7.8 to 8.6. The MCA-treated reference samples had an average rating of 8.8. Attack on these samples occurred directly above untreated feeder stakes.

Termite damage to the untreated control specimens was greater in Mississippi than in Ontario with average ratings of 1.5 with most specimens failing after 5-years of exposure (Figure 4). However, termite damage to the naturally durable species were similar to Ontario samples with average ratings ranging from 7.3 to 8.3. The MCA-treated reference samples had an average rating of 9.5. Though preliminary, these data suggest that non-preferred materials may perform similarly at both sites, while preferred materials (pine sapwood) may be more vulnerable at the Mississippi site.

At both sites the pale WRC had the lowest average termite ratings (greater attack) of the naturally durable species; however, the ratings were not much lower than for the red WRC. A longer exposure time is needed to determine whether there is a significant effect on termite resistance. Similarly, it's not possible to differentiate performance between the naturally durable species at this time. All are showing more resistance to biodegradation than the pine sapwood controls, and less resistance than the MCA-treated reference. The moderate termite resistance of these naturally durable species suggest that they could be used as part of an integrated protection strategy, particularly in areas with low termite hazards, or where other protection methods provide the bulk of the protection.

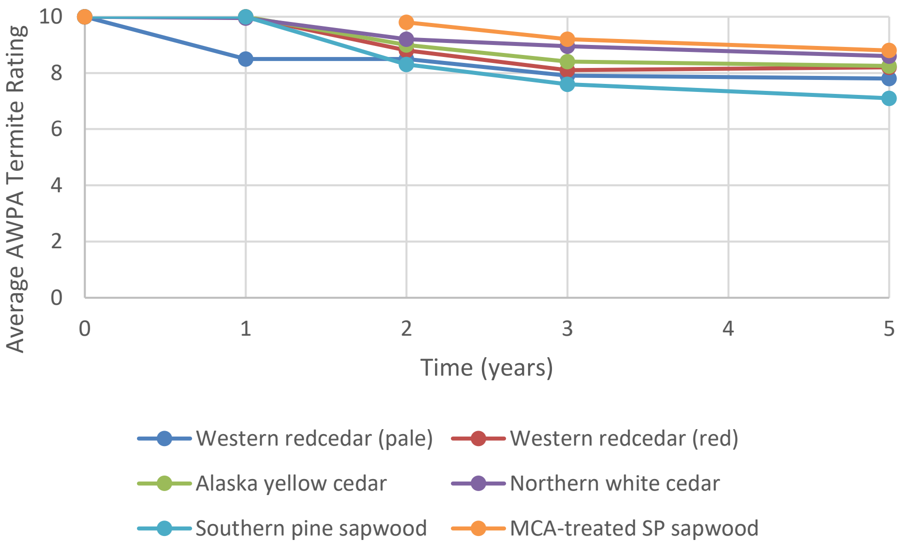

Figure 3: Average Extent of Termite Attack in Test Materials Exposed in Kincardine, Ontario.

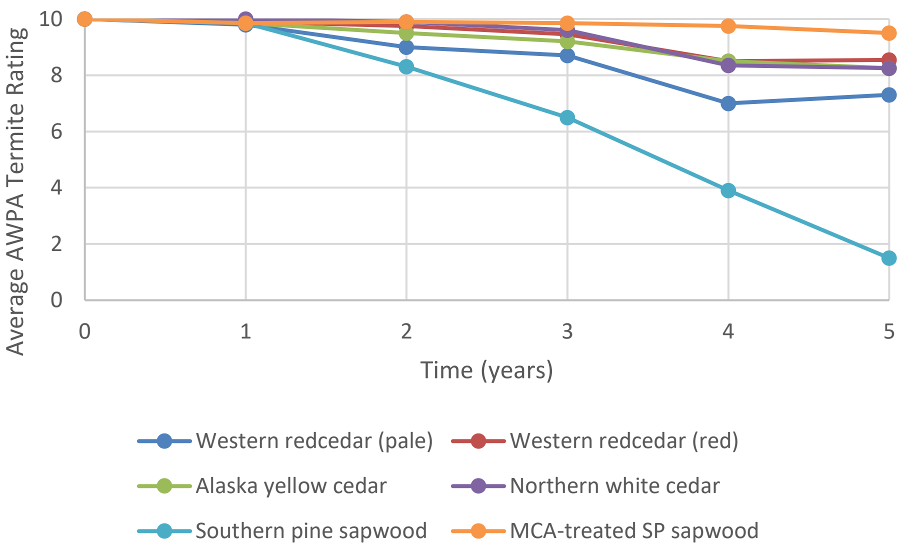

Figure 4: Average Extent of Termite Attack in Test Materials Exposed in Saucier, Mississippi.

4. CONCLUSIONS

- Decay was observed in test specimens at both sites suggesting that the AWPA E21 method could be used to evaluate decay resistance in UC2 exposures
- Termite attack was greater in the untreated pine sapwood controls in Mississippi than in Ontario, though similar in the naturally durable species and the MCA-treated reference.
- All naturally durable heartwoods evaluated were more resistant to termites than the untreated control, and less resistant than the MCA-treated reference
- More time is needed to define the service life of the naturally durable heartwood species tested here and to determine whether there are differences in their termite resistance.

5. ACKNOWLEDGEMENT

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