Above and In-Ground Performance of Naturally-Durable Woods in Wisconsin

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ABSTRACT

Naturally-durable wood species are offered as an alternative to chemically-treated wood for decking and siding. Restrictions on imports due to non-sustainable forest practices often limit the availability of tropical hardwoods, many of which are considered durable. The Forest Products Laboratory is evaluating native naturally-durable woods for use in covered bridge repair and rehabilitation in conjunction with the Federal Highway Administration to provide native alternatives to tropical hardwoods. Six wood species that are considered either invasive or underutilized were selected for both above ground and in-ground exposure in Madison, WI. Western red cedar (WRC), Alaskan yellow cedar (AYC) and untreated southern pine (SYP) were also included for comparison. Eastern red cedar (ERC), black locust (BL), honey mesquite (HM), and AYC are all still remaining durable in ground contact while Catalpa (CAT), WRC, SYP, and Paulownia (PAW) have failed. Data from both in-ground and above ground eight-year exposure in WI are presented herein and discussed.

Keywords: naturally-durable wood, field testing, underutilized wood species, invasive species, and biodeterioration

INTRODUCTION

Naturally-durable wood species are marketed as an environmentally friendly alternative to treated wood. Past efforts at the American Wood Protection Association (AWPA) to standardize naturally durable woods have been unsuccessful and are attributed to the inability to properly assess material behavior due to inherent variability in durability (Morris et al., 2012). This variability in resistance can be due to a wide range of external variables: age of tree, location within the tree, geographic location, silvacultural conditions, and chemical composition of the wood (Taylor et al., 2007). It is generally accepted that heartwood extractives impart a great deal of the durability (Hawley et al., 1924; Kirker et al., 2013) but underlying mechanisms that properly explain what makes durable wood resist insect and fungal attack remain unknown. Tropical hardwoods are frequently used in above and in-ground exposure due to their density, dimensional stability, and documented resistance to insect and fungal attack. However, concerns over deforestation and illegal logging can limit the usefulness of these species in certain applications (Shearman et al., 2012). Native North American durable wood species are a potential answer to this problem, with many endemic species that exhibit suitable material properties that are found in the continental United States. Additionally, several of these species are considered either invasive or underutilized; so more efficient harvest and utilization would result in reduced strain on private and federal forest ranges that are either past harvest maturity or impacted by invasive insect pests. As of 2014, it is estimated that the U.S. Hardwood inventory stands in excess of 10B m^3 and is growing at a rate of 40 million m^3 per year post harvest (NHLA). The goal of this study is to evaluate North American naturally-durable wood species in above ground and in limited ground exposure. The results presented in this paper are the compiled ratings after 8 years exposure in a moderate AWPA decay hazard setting both above and in-ground.

MATERIALS AND METHODS

Above ground tests

Above-ground durability was assessed at the Forest Products Laboratory exposure site near Madison, Wisconsin (decay hazard zone 2), using a modification of the E25-08 field test decking method (AWPA 2011a). Five untreated decking specimens (5.1 by 15.2 by 45.7 cm long or 2-in. by 6-in. nominal by 18-in. long) cut from each wood species were fastened to a simulated deck structure 91.4 cm (36 in.) above the ground at each test site. The exposure platform was designed so that the front edge of each specimen hung over the platform and the back edge of each specimen was flush with the platform and abutted a pine feeder (5 cm by 15 cm [2-in. by 6-in.] nominal) positioned at a 90° angle to the edge of the test specimen. Each year, the specimens were visually evaluated for decay, insect attack, dimensional stability (cupping and checking), and overall appearance. Specimens were rated according to E25-08 (AWPA 2011a) with additional measurements for cupping and checking recorded during each evaluation.

In-ground tests

In-ground durability was also assessed at the Forest Products Laboratory exposure site near Madison, Wisconsin (Fig 1) (decay hazard zone 2), using a modification of the E07-08 stake test (AWPA 2008). Durable wood stakes (18"x3/4"x3/4") were installed to approximately 9 inches into the soil on a randomized block design. Stakes have been rated annually for a period of eight years for decay damage using the 0-10 scale specified in the E07-08 standard (AWPA 2008), where 0 is failed (broken) and 10 is sound. Broken stakes were retained and sealed in zip lock bags for future genetic analysis of fungal colonists and extractive content of the failed stakes.

Figure 1: Native vegetation and field site conditions at the Valley View site. Scrub prairie with dense grasses predominate this site and the soil is a heavy clay.

RESULTS AND DISCUSSION

Above ground tests

After eight years of above ground exposure in Wisconsin, AYC, HM, ERC, and WRC all exhibit minimal checking (<1.5 out of 5) and cupping (<2.0mm deflection) (Fig 2). PAW, CAT, and SYP all exhibit higher checking and cupping. Regarding decay, CAT, PAW, and SYP are all beginning to show signs of decay throughout the decking piece, not just at the moisture catch. SYP has begun to fail (boards snap in half when flexed (Fig 3C)). For several of these species, the prevailing grain pattern and other anatomical features manifesting at the wood surface complicates visual ratings. For example, WRC weathers heavily between the latewood bands which results in a washboard surface that is not necessarily damage, but the current condition does deviate from the installed condition and may or may not be acceptable to the end user. Consumer acceptance of weathered uncoated wood is uncertain and extremely difficult to factor into ratings. Another interesting outlier is CAT, which has an unusual swirling grain pattern that appears to have differential susceptibility to white rot decay (note bleached areas on board next to arrow on Figure 3B). Almost all of the CAT boards are still sound at eight years, but these surface defects are notable flaws that are not currently covered by our rating scheme (not cupping, not checking). However, the boards sourced for this study may not be entirely representative of all catalpa decking, so further study would be required to substantiate our observations.

In-ground tests

After eight years of ground contact in Wisconsin, ERC is performing the best (9.7), followed by WJN (8.8), and BL (8.5), while HM and AYC are slightly more decayed in ground contact (7.8 and 6.8, respectively). At the end of the eight-year rating cycle, WRC and CAT have failed, SYP is near failing, and PAW failed only three years into the test. There are inherent difficulties in rating ¾" field stakes of low density softwoods such as the cedars (WRC and AYC especially). Few ratings below 7 are encountered as the stake will break easily once decay has initiated. A larger test specimen may be necessary to properly evaluate these species for future studies. Average ratings for the WI test are shown in Figure 4.

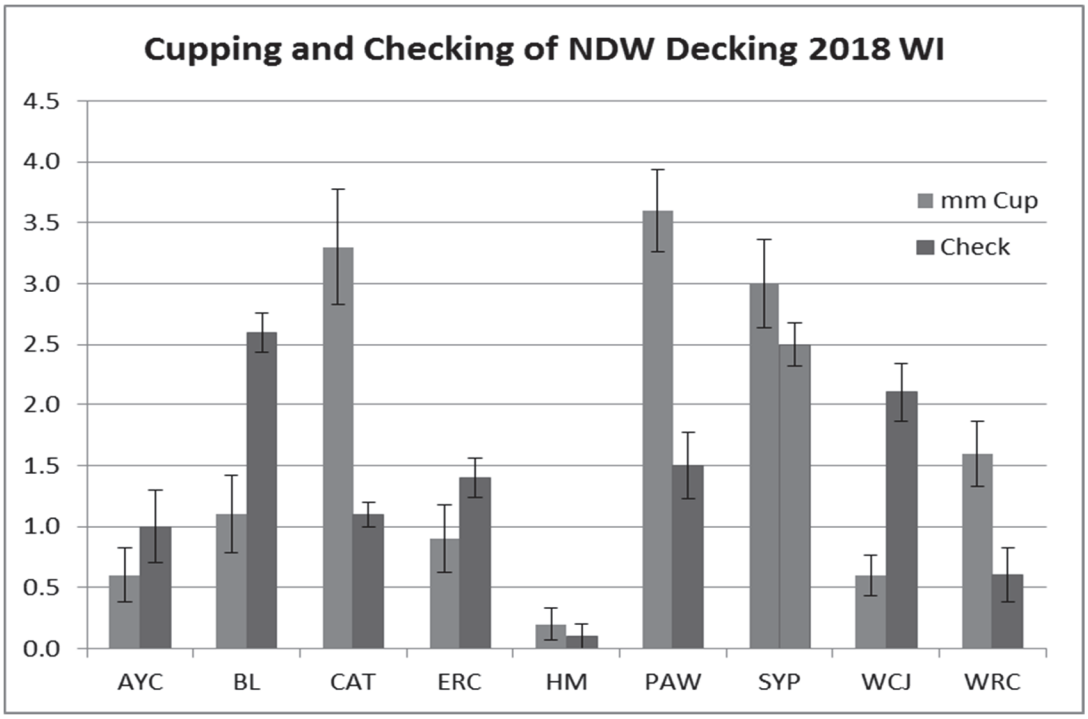

Figure 2A: Cupping and checking data of naturally-durable decking installed at Valley View site in WI after eight years of above ground exposure. Cupping is expressed as mm deflection from a straight edge and checking is a relative visual 0-5 scale where 0 indicates no checking and 5 indicates severe checking.

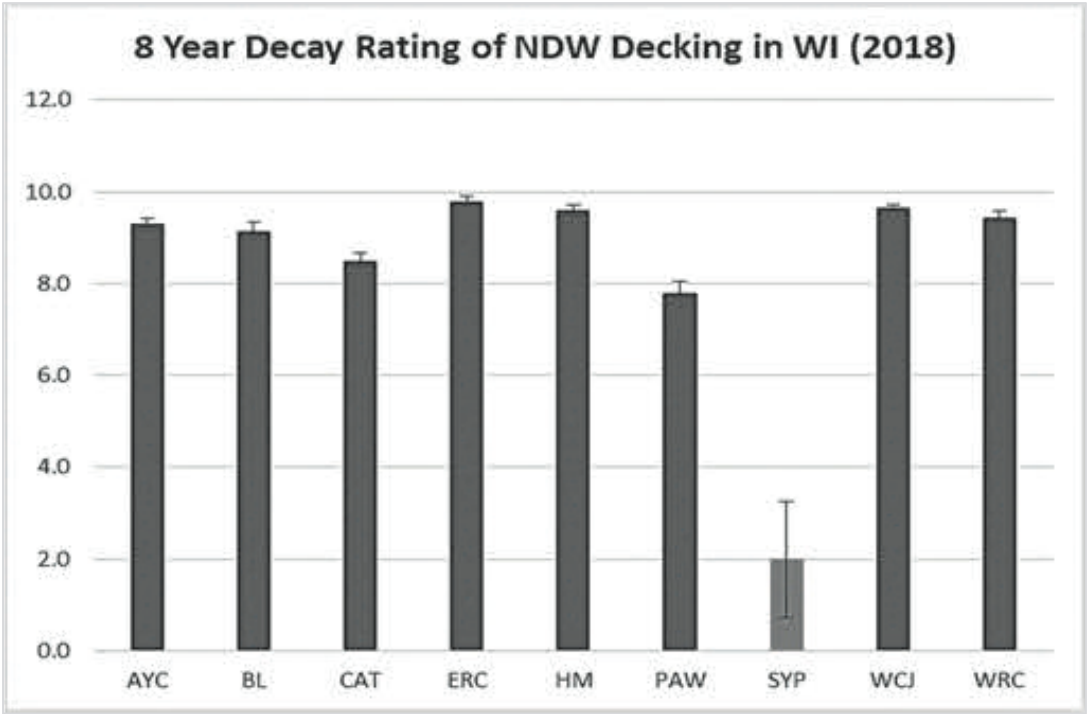

Figure 2B. Decay ratings from above ground exposed decking in WI after eight years. Ratings coincide with 0-10 scale specified in the E25-08 standard.

[A]

[B]

[C]

[D]

[E]

Figure 3. [A] General appearance of deck boards after eight years, [B] Surface defects characteristic of southern catalpa due to fungal decay, [C] Failed SYP decking specimen at the 8-year inspection, [D, E] Raised latewood of WRC due to UV degradation.

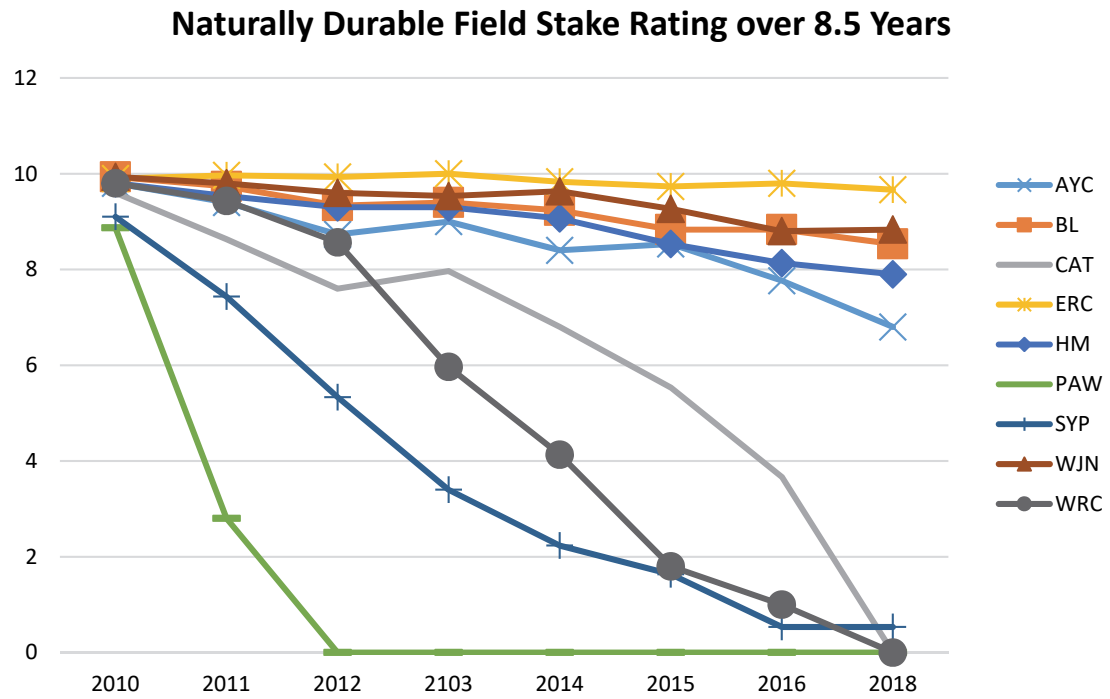

Figure 4: Average decay ratings of durable wood species over eight and a half years of ground contact exposure in WI. (AYC=Alaska yellow cedar, BL=black locust, CAT=catalpa, ERC=eastern red cedar, HM=honey mesquite, PAW=Paulownia, SYP=southern pine, WJN=western juniper, and WRC= western red cedar).

CONCLUSIONS

In the above ground tests, several of the wood species are performing quite well in WI. Honey mesquite, western juniper, and all of the cedars show little sign of deterioration above ground other than some greying attributed to UV degradation. Catalpa and Paulownia are both cupping severely and showing signs indicating development of decay. Black locust, western juniper, and eastern red cedar are performing well in-ground contact. Based on the in-ground data collected thus far, catalpa, paulownia, and western red cedar are not suitable for ground contact in WI, at least based on ¾" stake data. Larger sample size may be needed for further cedar testing due to density differences.

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DISCLAIMER

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