Decay resistance of China-fir (*Cunninghamia lanceolata* (Lambert) Hooker)

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Abstract

The decay resistance of China-fir (*Cunninghamia lanceolata*) was evaluated in several tests using white- and brown-rot fungi in an American Wood Preservers' Association soil-block test. Although there was some variation in weight loss among boards, China-fir heartwood was found to be similar in decay resistance to western redcedar (*Thuja plicata*) and should be classified as highly decay resistant.

China-fir (*Cunninghamia lanceolata* (Lambert) Hooker) grows at higher elevations in many areas of Southeast Asia, particularly in southern China, Laos, and Vietnam. This species has a reputation for producing naturally durable heartwood and has been extensively planted in China (Kunshan et al. 2005).

Many of these plantations are reaching harvestable ages and a number of importers have begun to bring this material into the United States for use as decking and other decorative exterior applications where durability is desired. While China-fir has a reputation for durability, there are concerns among potential users that this second-growth material may lack the durability of lumber from old-growth trees since there is evidence of this effect in other wood species (Taylor et al. 2002). In order to assess the potential decay resistance of these materials, the following study was undertaken.

Materials and methods

China-fir lumber was evaluated in three separate tests over a 3-year period. Boards were randomly selected from shipments into the United States and 19-mm cubes were cut from the heartwood in each board. In all, 15 boards were evaluated in the 3 tests and 12 blocks were cut from each board. In addition, 19-mm cubes were cut from ponderosa pine sapwood (*Pinus ponderosa* Laws) and western redcedar heartwood (*Thuja plicata* D Donn.) boards. The pine blocks served as decay-susceptible controls, while the western redcedar served as a positive, decay-resistant comparator (Scheffer and Morrell 1998).

The blocks were ovendried (103°C) and weighed prior to be being briefly soaked, and then sterilized by exposure to 2.5 mrad of ionizing radiation from a cobalt 60 source. The blocks were then exposed to either *Gloeophyllum trabeum* (Pers ex. Fr.) Murr (Isolate Madison 617) or *Trametes versicolor* (L. ex Fr.) Pilat (Isolate FP 101,664 -Sp) in a soil-block test according to procedures described in American Wood-Preservers' Association Standard E10 (AWPA 2004). Briefly, 454-mL glass French squares were half filled with soil and a wood feeder was placed on the surface. The moisture content was adjusted, then the jars were loosely capped and sterilized (121°C for 45 min), allowed to cool overnight and heated again for 15 minutes at 121°C. After cooling, a small plug cut from the edge of an actively growing culture of the respective fungus was placed on the edge of the wood feeder and the jars were incubated at room temperature until the fungus had completely covered the wood surface. The sterile blocks were then placed on the feeder surface and the jars were incubated for 12 weeks for the brown-rot fungus (*G. trabeum*) and 16 weeks for the white-rot fungus (*T. versicolor*). Six blocks were tested per fungus per board.

At the end of the test, the blocks were removed, scraped clean of adhering soil and fungal mycelium, weighed, ovendried, and weighed. The results were compared with those from the pine sapwood and western redcedar heartwood. Decay resistance was classified using the scale described in ASTM Standard D 2017 where highly resistant heartwood experiences 0 to 10 percent weight loss, resistant woods 11 to 24 percent weight loss, moderately resistant woods 25 to 44 percent weight loss, and non-resistant woods experience weight losses greater than 45 percent (ASTM 2001). Our method dif-

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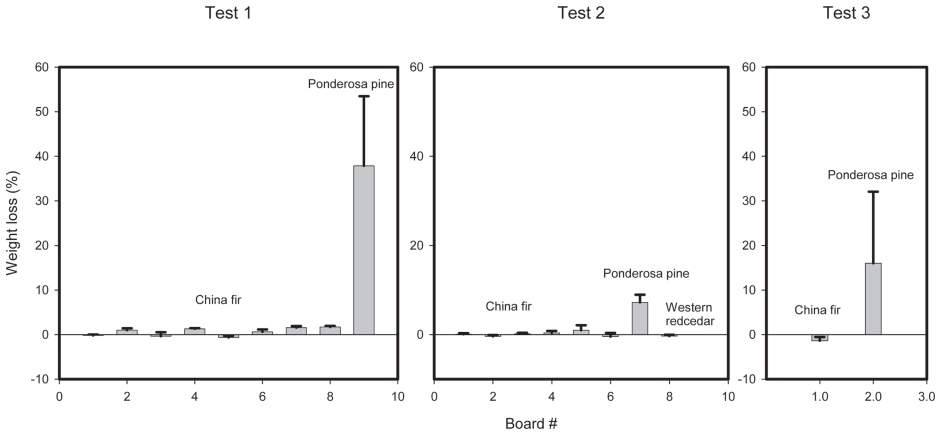

Figure 1. — Weight losses in C. lanceolata *heartwood blocks cut from 15 different boards and exposed to* G. trabeum *in an AWPA E10 soil-block test for 12 weeks. Ponderosa pine sapwood and western redcedar heartwood blocks were included as controls. Values represent means of six replicates, while error bars show one standard deviation.*

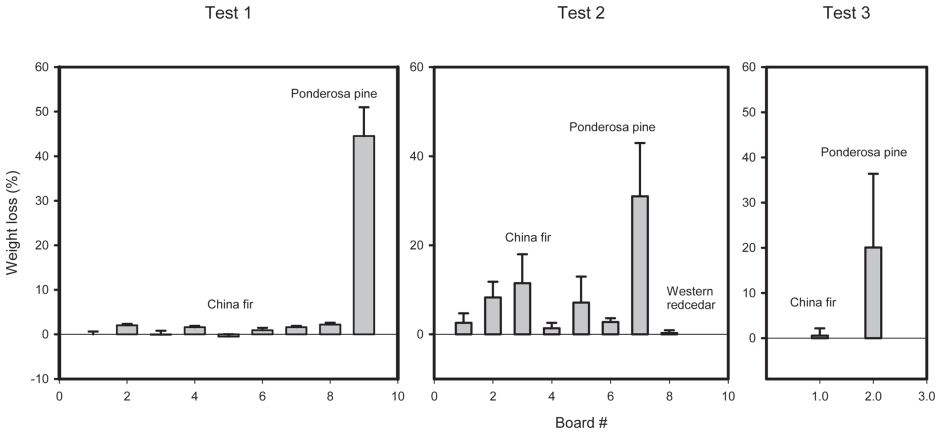

Figure 2. — Weight losses in C. lanceolata *heartwood blocks cut from 15 different boards and exposed to* T. versicolor *in an AWPA E10 soil-block test for 16 weeks. Ponderosa pine sapwood and western redcedar heartwood blocks were included as controls. Values represent means of six replicates, while error bars show one standard deviation.*

fered slightly because we used an arbitrary 12-week test, while the ASTM method is based upon the weight loss of pine sapwood controls.

Results and discussion

Weight losses for ponderosa pine controls exposed to *G. trabeum* ranged from 7.2 to 44.5 percent (**Fig. 1**). In several instances, weight losses for the pine blocks were somewhat lower than would normally be found in a decay test, particularly for the *G. trabeum* exposures; however, weight losses were generally high enough to delineate differences in decay resistance. The lowest weight loses for this fungus occurred in Test 2 and appeared to reflect excess moisture in the pine blocks, which may have inhibited fungal attack. Moisture levels in the China-fir blocks were not excessive, leading us to include these results in our study.

Weight losses for western redcedar heartwood averaged −0.35 and 0.32 percent for *G. trabeum* and *T. versicolor*, respectively, illustrating the excellent decay resistance of this species. Mean weight losses for China-fir blocks exposed to *G. trabeum* ranged from −1.36 to 1.71 percent (**Fig. 1**) and the blocks were largely free of fungal attack at the end of the test period.

Weight losses for blocks exposed to *T. versicolor* varied more widely, from a low of −0.49 to 11.49 percent (**Fig. 2**). In general, samples exposed to the white-rot fungus experienced low weight losses, but blocks from three boards experienced mean weight losses ranging from 7.28 to 11.49 percent. It is unclear why these boards were so much more susceptible to fungal attack, especially to a white-rot fungus, although it is possible that some sapwood was inadvertently included in these samples or that these boards were cut from zones of the heartwood that were less durable (blocks were only cut from zones free of visible sapwood). White-rot fungi typically cause lower weight losses on coniferous woods than brown rotters in this test. This variation may reflect the natural range of decay resistance of wood of this species. Based upon the weight losses obtained, the material examined would be classified as highly decay resistant according to the ASTM Standard classification.

Conclusion

Although there was some variation in the durability of individual boards, the China-fir evaluated in these studies was classified as highly resistant to fungal attack, a classification that is similar to that given to western redcedar.

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