How Durable is Northern White Cedar?
Michigan State University
Cooperative Extension Service
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February 1977
8 pages

Extension Bulletin E-929

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COOPERATIVE EXTENSION SERVICE • MICHIGAN STATE UNIVERSITY

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INTRODUCTION

Northern white cedar is one of the most plentiful softwoods in Michigan, especially in the north.

This wood's reputation for decay resistance has led to its use for fence posts, log houses and shingles.

Since one of its properties is natural durability (used here in the sense of resistance to decay and other biological agents) a logical question to ask is: "How resistant *is* cedar?"

Durability of round posts

After 13 years in the ground at East Lansing, 30% of the untreated round cedar posts (averaging 4 in. in diameter at the top) were removed because of decay and 70% contained some decay. The estimated life of the group is 16 years. Tests in Wisconsin indicate an average life of 19 years. On the other hand, a similar group of cedar posts pressure treated with 4.2 lb. of 5% pentachlorophenol solution per cubic foot in oil is 100% sound after 13 years. Untreated Jack pine posts have an average life of about 3 years.

Although cedar posts and poles have a long useful life when used untreated, they will not last as long as pine posts or cedar posts that have been adequately treated with a suitable wood preservative. Thermal (hot immersion in preservative followed by cold immersion) treatment is usually applied.

Unlike pine, cedar sapwood is not very permeable to wood preservatives. Thus, mere soaking in a preservative is usually insufficient to extend post life by half or more. Untreated cedar sapwood is no more durable in soil contact than pine or other species. Above ground, however, soak-treated sapwood will be resistant to decay and discoloring stain or molds because the exposure is not as severe as soil contact. Figure 1 compares treated and untreated cedar with jack pine, commonly used for posts in Michigan.

Cedar Poles

White cedar poles have been widely used throughout the Lake States and provinces of Canada, although there are few new installations. Quality is high but there are not enough of the sizes needed by electric power companies, the main consumer. White cedar has more taper than other pole species which results in poles of larger diameter at the ground-line for a given height. Consequently, cedar poles last longer not only because of resistant wood but also because once decay begins, it takes more time for the wood to rot down to an unsafe diameter.

Untreated poles in line have an average life of 20 years in central Illinois or 22 years in Saskatchewan (Fig. 2). Individual poles may last up to 40 years but some could decay in less than 20 years. When a preservative like creosote or pentachlorophenol is applied to cedar poles by the thermal process an average life of 34 years can be expected.

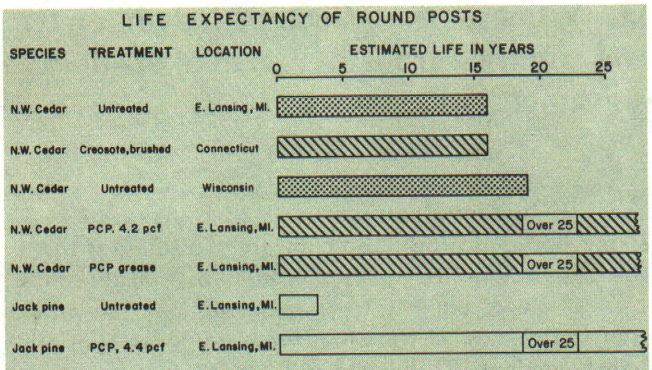


Fig. 1. Probable useful life of round white cedar posts used in various localities compared to jackpine, untreated and treated.

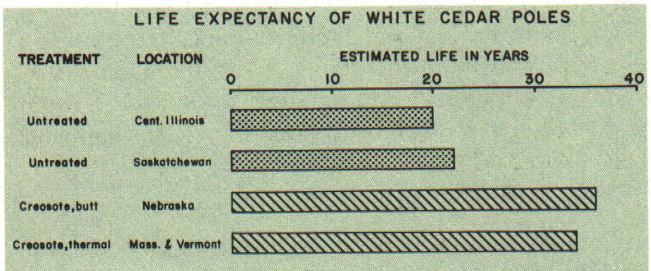


Fig. 2. Estimated life of treated and untreated white cedar poles in United States and Canada.

Q. How durable is rectangular heartwood?

A. It is not valid to extrapolate life expectancy of round posts to square or rectangular timbers, because of the difference in form and exposure. The surrounding sapwood on round posts delays entrance of decay into the heartwood. Square or cornered wood exposes more surface per volume which results in a faster loss of extractives from the wood.

There are no published records of the length of useful life of cedar timbers, probably because there are few applications in this form. Usually small stakes are used to measure resistance to decay and insects because they yield results faster than large-dimension timbers. For example, a ¾ in. square stake is the standard test unit because susceptible woods will be destroyed by decay or termites in a year while the same wood treated with preservative might have a life of 5 years. If 4 x 4's were used, these periods might be extended three times.

Q. Is all the wood in cedar trees equally durable?

A. No. Cedar sapwood is as susceptible to decay or termite attack as any other sapwood. Little is known about branch wood, as it constitutes only a small portion of the tree and is not suitable for lumber.

Extensive laboratory experiments have been conducted on cedar from bottom, middle and top sections of cedar tree tunks. Butt log heartwood is most resistant to decay and that from the middle least resistant. Top heartwood is intermediate in this group, more like butt heartwood in decay resistance. These results were from a group of 30 trees that came from a poorly drained cedar swamp. In a Mississippi test plot using ¾ in. stakes driven into the ground half their length, butt wood is proving more decay resistant than that from other logs (Fig 3). Figure 3 also compares inner heartwood with outer. Outer butt heartwood is more decay resistant than inner heartwood in this group of trees.

Laboratory tests were conducted on cedar from various heights in the trunk using ten trees grown on well drained soil underlain with limestone. Relative durability for bog grown wood paralleled that for upland wood. Field stake tests confirmed laboratory tests. Results of inspection of upland cedar stakes installed in the same test plot as the bog cedar are shown in Figure 4.

Outer heartwood cut near the sapwood is more resistant than inner heartwood. Butt inner heartwood is the least resistant of any heartwood according to this test.

Q. How much variability is there in decay resistance between trees?

A. Considerable! Heartwood of some cedar trees is much more decay resistant than that from other trees. This is a characteristic of the tree and not necessarily due to the conditions under which it grew. As an example, the average decay weight loss for heartwood from all parts of tree 7 (bog grown) using two common decay fungi in a standard laboratory test was 17.8%. Weight loss was 0.7% for tree 11 from the same location. Field plot decay ratings confirm these differences. On a scale designating 100 as sound and 0 as destroyed by decay, after 4 years in a Mississippi test plot decay rating for all stakes from tree 7 was 45 but was 65 for those from tree 11.

The difference in decay resistance between trees is more evident with inner heartwood than with outer. Tree 7 top inner heartwood lost 41.4% by decay while tree 8 top inner heartwood lost only 0.3% as an extreme case.

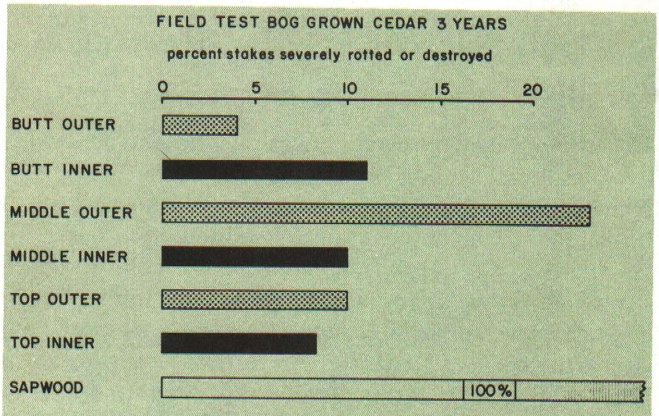


Fig. 3. Comparison of bog grown white cedar heartwood using ¾ in. square stakes exposed in southern Mississippi.

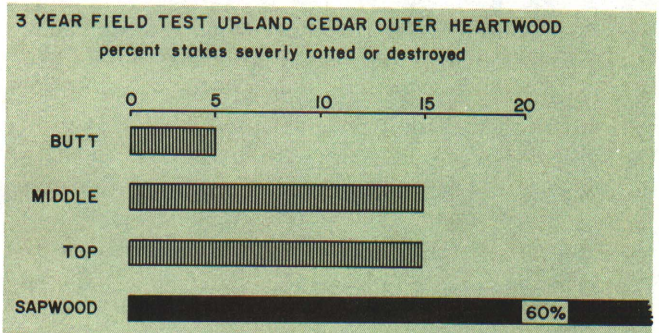


Fig. 4. Comparison of upland grown white cedar outer heartwood using ¾ in. stakes exposed in southern Mississippi.

Unfortunately, there is no simple way to tell which trees will yield the most durable wood. No aspect of the appearance of a cedar tree or of the heartwood gives any clue to its ultimate decay resistance. Growth rate is no indicator of decay or termite resistance.

Q. What is the effect of place of growth on decay resistance?

A. Wood from trees growing in five locations was laboratory tested. The locations were bog ground from Black Lake State Forest, north of Onaway, Michigan and upland areas from the same forest near Grand Lake; Baraga County, Michigan; the vincinity of Powers, Michigan, and Orleans County, Vermont.

The wood from one location was not appreciably more decay resistant than that from any other. There are greater differences in average decay weight losses between trees from one location than between trees from different locations. These conclusions are based on standard laboratory soil block test. They are confirmed by field stake tests.

Q. What is the effect of log diameter and distance from tree center on decay resistance?

A. Extreme of log diameters tested averaged 19.7 in. for Baraga County and 5 in. for the smallest three logs designated *Powers*. If the outer butt heartwoods from all five groups of trees are compared, only that from the smaller Powers logs was less decay resistant than the others. This could indicate that outer heartwood from larger trees (over 5 or 6 in. in diameter) is more decay resistant and should be used for hazardous locations instead of small tree wood. It may also help explain why poles last longer than posts.

If inner butt heartwoods are compared by laboratory testing, both Powers and Baraga County trees are less decay resistant than the others. Thus, the inner heartwood of the largest and smallest trees decays more readily than the inner heartwood of middle diameter trees, 6 to 12 in.

When tested as stakes in Florida the Powers group again has the poorest decay resistance. The picture for the others is not as clear.

Regardless of tree size, outer heartwood from butt logs is equal to or better than inner heartwood in decay resistance. This is fortunate because there is more wood volume in the outer portion than the inner. For example, assume a log or tree has a heartwood 10 in. in diameter and the outer 5 in. is more resistant. The log would contain 75% "outer" heartwood and 25% less-resistant "inner" heartwood. It wouldn't necessarily yield proportionate amounts of lumber, but the greater volume for outer heartwood would prevail.

The division of a log cross-section into inner and outer heartwood is arbitrary. With logs of the diameter range 5 to 12 in. only two parts were sampled. Inner heart was cut as close to the tree center as possible while still avoiding decay. Outer heart samples were cut as close to the sapwood as possible. For all but the large Baraga County trees no samples were taken of the wood in between which could represent 3 in. along a radius. Baraga County logs ranged from 14.5 to 22 in. in diameter, and six of the seven logs examined were 17 in. or more in diameter. Since these logs contained much more wood than any of the other logs tested they were sampled at four places along a radius from the tree center to the heartwood-sapwood boundary. There was a gradual increase in decay resistance of wood outward from the pith. Figure 5 shows this for field specimens.

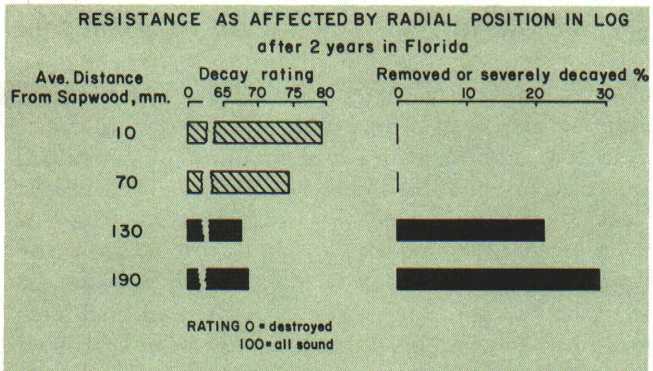


Fig. 5. Resistance of white cedar heartwood from large logs exposed in north Florida.

Q. How does application affect decay resistance?

A. If wood is kept dry it will not decay even if the relative humidity of air surrounding it is high. As long as liquid water is not present in or on the wood surface, decay will not occur. Since cedar heartwood is known to be more resistant to rot than many other woods, it is frequently used where decay is a threat. In fact, cedar is purposely used in hazardous applications.

Contact with soil offers a greater threat to wood's service life than above-ground use. A fence post is likely to be attacked by decay or termites in a shorter time than a guard rail or board nailed to the post. Likewise, a landscaping timber is not likely to last as long as house trim. When a cedar heartwood stake is driven into the soil, rain and ground water slowly dissolve the extractives largely responsible for decay resistance. After the extractives are leached from the surface layer, decay fungi rot the wood. If the stake is removed from the soil a shell of rotted wood sloughs off allowing further leaching. Even if a test stake were not disturbed, leaching would gradually remove all the decay-retarding extractives, probably at a slower rate. Where cedar is away from soil contact leaching is much less severe. In addition, the wood dries faster after a rain which reduces decay hazard. Soil contains many micro-organisms besides decay fungi. These probably predispose cedar to earlier rot just as they do preserved wood.

Q. How does cedar compare with other woods and preserved wood in decay and termite resistance?

A. New uses must be found for cedar before its popularity will increase. It will have to compete with preserved wood and other naturally durable woods such as redwood or western cedars. Direct comparisons have been conducted in Florida (Fig. 6).

In conditions of direct soil contact redwood appears to be slightly more resistant than white cedar to termites and decay. Although both woods are far more resistant than untreated southern pine sapwood, if the latter is impregnated with 0.15 lb. of CCA type C preservative per cubic foot it is superior to both cedar and redwood in tests. In practice 0.4 lb. per cubic foot are used.

If all the woods to be compared are exposed to favor termite attack and reduce decay to a minimum, northern white cedar and redwood are about equal. Western red cedar and Alaska yellow cedar appeared to be slightly inferior but the test sample was smaller so the difference may not be real. Southern pine pressure treated with 0.17 pcf of CCA type C preservative is slightly superior to any of the naturally durable woods (Fig. 7).

For some uses northern white cedar would have a hard time competing with treated wood. Accordingly, its best markets are likely those where decay and termite hazard is not so great or where treated wood is too expensive or otherwise not practical.

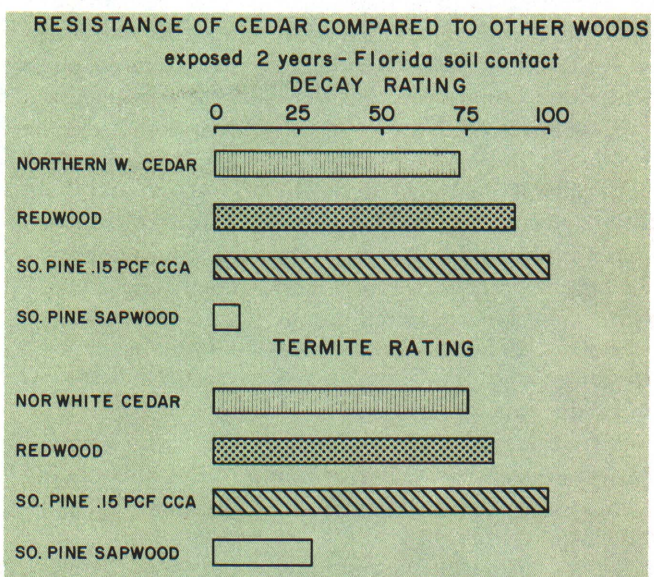


Fig. 6. Resistance of white cedar heartwood compared with other heartwoods or treated wood and a non-resistant sapwood exposed as ¾ in. square stakes.

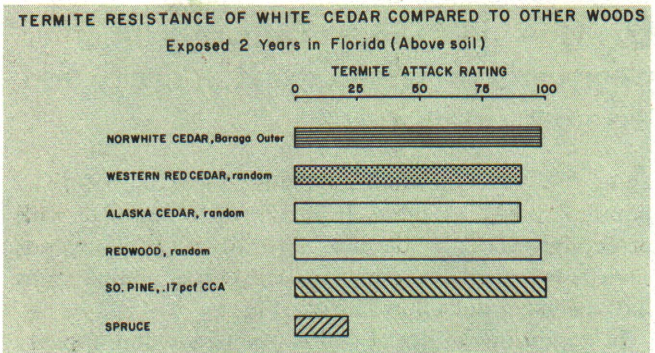


Fig. 7. Termite resistance of various heartwoods compared to untreated spruce and southern pine treated with CCA preservative. Exposed as small boards without soil contact. No Attack = 100. Destroyed = 0.

Q. What about termite resistance?

A. Most of this discussion has centered on decay resistance because damage by decay to wood and wood structures is greater than that by termites, and more cedar is used in situations where decay is a greater threat than termites. Termite resistance is important, however, in much of the United States and Puerto Rico and other tropical locations. Even in Michigan termite infestation is common in most of the southwestern counties and those bordering on Lake Michigan as far north as Manistee.

Northern white cedar has about the same or slightly better resistance to subterranean termites as it does to decay (Fig. 6, 7). For other relationships the two forms of resistance are about parallel, too. For example, outer heartwood is more resistant than inner heartwood, and butt log heartwood is more resistant than top or middle wood.

All termite damage in both laboratory and field testing was by native subterranean termites *(Reticulitermes flavipes* or *virginicus)*. The wood was not tested against dry wood termites or tropical kinds. This should be considered in making recommendations for uses in the Virgin Islands, Mexico, Bahamas, Puerto Rico, the West Indies, and parts of Gulf Coast States and California.

There is an indication that termites will attack fungus stained areas of cedar in preference to the surrounding wood, so avoid using fungus stained heartwood in termite infested areas.

Cedar is generally as safe to use where termites are a problem as where decay is. Cedar's termite resistance lasts longer if the wood is used away from soil and leaching by rain.

Q. What about internal rot in cedar?

A. Decay in the center heartwood of cedar is common in old trees. The group from Baraga County averaged about 200 years and almost all contained some rot. About 50% of the bog grown trees from Black Lake State Forest contained rot. These trees ranged from 46 to 132 years old, averaging 74 years. In contrast, the group from Grand Lake which averaged 55 years had no rot. Since these trees were selected from wet and dry locations, this is probably an indication of more internal rot on poorly drained soils. No systematic study of the prevalence of decay in northern white cedar trees has been reported. However, the fungi causing most of the decay are known to be *Poria subacida* (stringy butt rot) and *Polyporus balsameus* (brown butt rot). The former fungus does not form fruiting bodies on the tree making decay detection on standing trees difficult.

Samples of heartwood cut close to decayed parts of logs were no more or less susceptible to decay test fungi in the laboratory than wood from sound trees. Field tests lead to the same conclusion about decay and termite attack. In fact, wood cut next to decayed heartwood may be more resistant when tested as a stake. Since stakes are not sterilized before testing, this test plot behavior indicates that rot present in the standing tree does not continue to grow in lumber cut from logs with internal rot or else it does not spread much beyond the decay zone in the log.

Q. Can durability of cedar heartwood be improved?

A. Most cedar is treated by the thermal process in the round form with sapwood present. This gives satisfactory penetration in incised sapwood. Cedar heartwood is very difficult to penetrate even under pressure. Because cedar is a weak wood, pressures must be kept below 100 psi. Pressure limitation accounts for some of the difficulty but anatomy is the main reason. Little heartwood is treated since it already is decay resistant. Since most cedar is treated in the round form, its poor heartwood penetrability is not important. If cedar is to be used as boards or dimension lumber, however, treatment of the heartwood might be necessary. There is no published information on the benefit that a superficial treatment or pressure treatment might provide. Superficial treatment would likely be the only economically feasible treatment.

SUMMARY

Northern white cedar deserves to be classed as a durable wood because it resists decay and subterranean termites. The estimated life of round fence posts exposed in Central Michigan is 16 years compared to 3 years for jack pine. Cornered timbers in a similar situation might have a shorter life because of the greater surface exposed. Sapwood is readily decayed in soil contact.

Heartwood from the butt log away from the tree center is most resistant to decay and termites. The top log is more resistant than the middle log. Outer heartwood is more decay resistant than inner heartwood but this is not of much practical importance except for large trees (over 15 in. in diameter) and small ones (less than 5 in. in diameter). Where logs are large enough to cut several boards between pith and sapwood, a gradual increase in decay resistance will be found.

Cedar is not resistant to the dry rot fungus, *Poria incrassata*, and the wood should not be used where this species is growing under favorable conditions. Where the wood dries out between wettings the fungus dies.

Cedar heartwood not only varies in decay resistance within parts of the same tree but also between trees. Heartwood from some trees is more resistant than that from others by as much as 50%. There is no way to predict this difference.

Wood from one area of growth is not appreciably more resistant than that from another. If individual trees are considered,there can be as much variation of decay resistance between trees in one location as between trees in different locations.

Northern white cedar is about equal in decay and termite resistance to western red cedar and slightly less so than redwood. Southern pine thoroughly impregnated with 0.4 lb. of CCA preservative per cubic foot is superior in durability to any of these woods when used in soil contact.

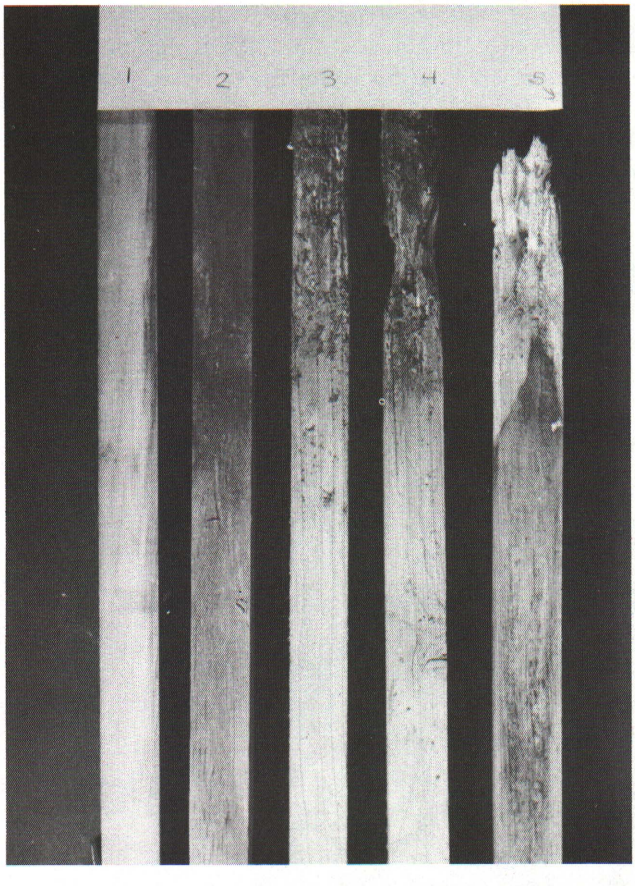
Resistance to subterranean termite attack parallels that to decay. There is an indication that termites will eat blue stained cedar heartwood in preference to unstained wood.

Northern white cedar should be directed toward uses that take advantage of its natural durability and termite resistance. Round posts and poles, preferably with treated sapwood, will give long service. It should find its most favorable applications in situations of intermediate hazard such as exterior trim, furring strips, trellises, fence boards, and other items where light weight is an advantage.

Small office building built largely of cedar. Cedar's decay resistance gives it an advantage over most other woods for exterior applications such as these.

Cedar poles debarked and awaiting use. Maximum advantage is taken of cedar's decay resistance for this use.

Typical upland stand of cedar along Highway 2 in Michigan's Upper Peninsula.



How stakes are evaluated for decay resistance for ratings in Fig. 5 and 6. One rates 100, 2-90, 3-70, 4-40, and 5-0.

Cedar logs awaiting use. Note decay in the larger ones.

If cedar is to be treated or finished, all the bark must be removed as is being done here.

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