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Field Performance of Wood Preservative Systems in Secondary Timber Species

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ABSTRACT

The objective of this ongoing study is to evaluate the performance of new, potential, and standard wood preservative systems in secondary North American timber species. Eleven preservative systems were evaluated in this study - ACQ Type B, Copper Citrate 2:1, CDDC, chlorothalonil/chlorpyrifos, copper-8-quinolinolate, tebuconazole/chlorpyrifos, RH287, propiconazole/chlorpytifos, copper naphthenate, CCA and creosote. Field evaluations are being performed with ground contact field stakes and termite-specific testing in Hawaii, along with laboratory soil bed tests. The major wood species used with all the systems and evaluation methodologies are loblolly pine, northern red oak, tulip poplar, and cottonwood. More limited evaluations (field stakes only) are being conducted with eastern hemlock, red maple, and sweetgum. Information is presented from laboratory soil bed, field termite, and field stake evaluations. There is good correspondence between soil bed and field stake results. The more highly developed preservative systems and those in an AWPA P9 Type A oil carrier tend to perform better, and there can be a strong affect on performance from the wood species.

Key words: Wood preservative, hardwood, softwood, field stakes, soil bed.

INTRODUCTION

The purpose of the work reported in this paper was to generate data on the performance of new and upcoming preservative systems in important (and potentially important) wood species using complexes of decay organisms. When correlated with laboratory efficacy results and strength property evaluations, the combined data base will allow the design of timber bridges and other non-residential outdoor wood structures using an appropriate preservative for locally available North American wood species. Eleven wood preservative systems were used (ACQ Type B, ammoniacal copper citrate 2:1,

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copper dimethyldithiocarbamate, copper-8-quinolinolate, tebuconazole/chlorpyrifos, RH287, propiconazole/pyrethroid, chlorothalonil/chlorpyrifos, copper naphthenate, CCA, and creosote) in three test methodologies:

1. A field stake test in Hawaii where the decay hazard is a mixture of basidiomycetes and soft rot fungi.

2. A soil bed test where the moisture content of the soil is maintained at a level that promotes soft rot attack.

2. An out-of-ground-contact termite test with *Coptotermes formosanus* in Hawaii.

The field stake work is the most comprehensive. The eleven wood preservative systems were evaluated at 4 retentions bracketing the manufacturer-specified ground-contact retention using four key wood species - red oak *(Quercus rubra* L.), yellow-poplar *(Liriodendron tulipfera* L.), cottonwood *(Populus deltoides* Bartr.ex Marsh.) and southern pine *(Pinus* spp.). In addition, field stakes were prepared with three additional wood species - red maple *(Acer rubrum* L.), sweetgum *(Liquidambar styraciflua* L.), and eastern hemlock *(Tsuga canadensis* [L.] Carr.) - where the eleven wood preservatives were applied at only one retention. The four key wood species were also evaluated in the soil bed and termite testing, again at only one retention - the manufacturer-specified ground-contact loading.

METHODOLOGY

Specimens treated were field stakes (19x19x450 mm), soil bed stakes (12x25x200 mm), and termite blocks (25x50x125 mm). Only sapwood was used for southern pine, sweetgum, and yellow-poplar, while all red oak specimens were heartwood. No attempt was made to distinguish heartwood and sapwood for cottonwood, red maple, and eastern hemlock because of the difficulty in identifying the heartwood in these species. To maximize consistency in southern pine wood density, only wood with between 6 and 10 annual rings per inch was used.

The specimens were allowed to condition to ambient room conditions for a period of several months prior to treating. Specimens were placed in metal containers and weighted down using aluminum blocks, with plastic mesh between layers, between the stakes and the container, and between the stakes and the weights to ensure maximum contact with the treating solutions. Following submersion of the stakes in the treating solution, the container was placed in a treating cylinder, where a vacuum of 17.3 kPa (30 minutes) followed by pressurization at 790 kPa (1 hour) was appplied. The stakes were then allowed to remain submerged in the treating solution for a 10 minute equalization period. Finally, the stakes were blotted dry, weighed, and placed in a second conditioning room to allow evaporation of the carriers and solvents. Retentions based on the amount of active ingredient retained by the stakes were calculated using the pre- and post-treated weights, stake volume, and active ingredient concentration in the treating solution. CDDC was the only system requiring more than one treatment. The first was treatment of the wood with a copper-amine water solution

(cupric hydroxide). The stakes were allowed to dry to ambient conditions for several months before the second treatment, which was sodium dimethyldithiocarbamate (SDDC) in water. Active ingredient retentions for CDDC are based on the retention of copper hydroxide + SDDC.

Wood preservative formulations and target retentions for the field, soil bed, and termite specimens are listed in Table 1. The primary wood species (southern pine, red oak, yellow poplar, and cottonwood) were used in all tests and retentions. The secondary wood species (eastern hemlock, red maple, and sweetgum) were only used in the field stakes at a single retention per formulation, which corresponds to the standard or expected commercial ground contact retention (second highest retention in the sequence given in Table 1, except for CC where the lowest test retention is the AWPA-specified retention for pine in ground contact). Wood preservative formulations were supplied by the manufacturer listed in Table 1. Test retentions and, in some cases, carrier systems were chosen in consultation with the manufacturer.

Field stakes and termite specimens were installed in or near Hilo, Hawaii (mean annual precipitation - 332 cm, mean annual temperature - 23°C). The field stakes were installed and evaluated according to AWPA Standard E7-93 (1). The termite test methodology is described elsewhere (2).

DISCUSSION

Table 2 summarizes the mean field and soil bed ratings. The decay rate in the soil bed evaluation was higher compared to the field stake exposure. Figure 1 compares the field decay ratings of CCA at 1.6, 3.2, 6.4, and 12.8 kg/m^3 after 16 months exposure to 6.4 kg/m^3 CCA in the soil bed after 18 months. The 6.4 kg/m^3 soil bed stakes have similar ratings to the 1.6 kg/m^3 field stakes showing the higher decay rate in the soil bed.

Figure 1 also shows the differential performance amongst the wood species. CCA consistently performs better in southern pine compared to the other species, and ratings for the lower density hardwoods (yellow poplar and cottonwood) are lower than for the denser red oak. Besides density, another difference between red oak and the other hardwoods which may contribute to the performance difference are the extractives in the red oak heartwood. This relative performance of a wood preservative system in the different wood species was observed with a number of systems. Figure 2 shows the average ratings for the four wood species treated with 4.8/0/28 kg/m^3 CTL/CPF, 6.4 kg/m^3 CCA, 0.96/0.48 kg/m^3 PRP/Pyr, 0.96 kg/m^3 RH287, and untreated stakes after 27 months exposure in the soil bed. The same relative wood species performance is observed with the pine performing the best. With other preservative systems, there was little effect of wood species on soil bed performance. The 27 month soil bed data (Table 2) show ACQ, CC, CU-8, CuNap, and creosote performing similarly across the four wood species with ratings in the 8 to 9 range. Other systems had intermediate performance.

Results similar to the soil bed are observed with the field stakes. The stake site used has minimal termite activity. The greatest exposure effect is seen in the decay ratings.

Table 1. Wood preservative formulations used in this work and the target retentions for field stake, soil bed, and termite testing

System	Manufacturer	Acronym	Formulation/ Carrier	Field Stake Retentions	Soil Bed/ Termite Retention
				- kg/m3 -	- kg/m3 -
Ammoniacal Copper Quat Type B	CSI/Laporte	ACQ	Water/NH_3	1.6, 3.2, 6.4, 12.8	6.4
Ammoniacal Copper Citrate	Osmose	CC	Water/NH_3	6.4, 9.6, 12.8, 16.0	6.4
Copper Dimethyl-dithiocarbamate[2]	ISK Biosciences	CDDC	Amine/Water	4.6, 9.3, 18.6, 27.8	9.3
Copper-8-Quinolinolate	Morton International	Cu-8	P9 A Oil[1]	1.3, 2.4, 4.8, 9.6	4.8
Tebuconazole/Chlorpyrifos	Bayer/DowElanco	TEB/CPF	P9 A Oil[1]	0.24, 0.48, 0.96,1.92 /0.28	0.96/0.28
4,5-Dichloro-2n-Octyl-4-isothiazole-3-one	Rohm & Haas	RH287	Toluene	0.24, 0.48, 0.96,1.92	0.96
Propiconazole/Pyrethroid	Janssen	PRP/Pyr	Emulsion	0.24, 0.48, 0.96,1.92 /0.48	0.96/0.48
Chlorothalonil/Chlorpyrifos	ISK Biosciences	CTL/CPF	P9 A Oil[1]	1.6, 3.2, 4.8, 6.4 /0.28	4.8./0.28
Copper Naphthenate[3]	OMG	CuNap	P9 A Oil[1]	0.24, 0.48, 0.96,1.92	0.96
Creosote	Koppers Industries	Creosote	----------	40, 80, 160, 320	160
Chromated Copper Arsenate Type C	various	CCA	Water	1.6, 3.2, 6.4, 12.8	6.4

[1] P9 A Oil Retention = 7.0 pcf
[2] Retentions for CDDC expressed as total of cupric hydroxide and sodium dimethyldithiocarbamate retentions.
[3] Retentions for copper naphthenate based on copper only.

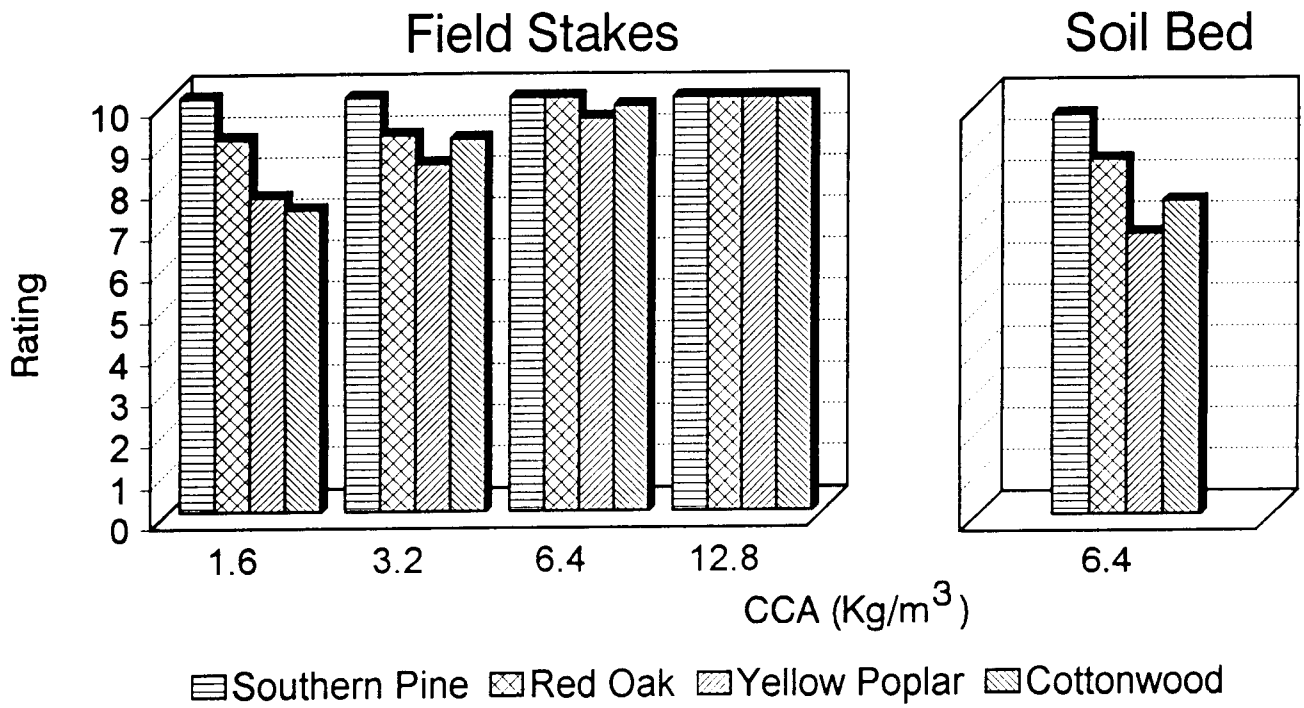

Figure 1. Average decay ratings for CCA field stakes at 1.6, 3.2, 6.4, and 12.8 kg/m^3 after 16 months exposure compared to 6.4 kg/m^3 CCA soil bed stakes after 18 months.

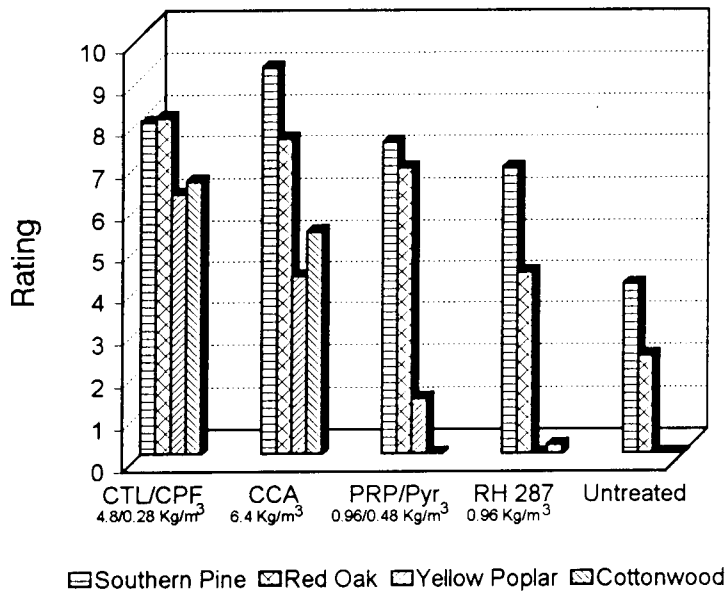

Figure 2. Average soil bed stake ratings for CTL/CPF, CCA, PRP/Pyr, RH287, and untreated stakes.

In general with both sets of results, the more highly developed commercial systems (ACQ, CC, CDDC, CCA, creosote) and the organic systems applied in an AWPA P9 Type A oil carrier (Cu-8, TEB/CPF, CTL/CPF, CuNap) tend to perform better, although there are some distinctions among these groups. For example, ACQ performs well in all the wood species, while CCA has distinctly better performance in southern pine compared to the hardwoods. The commercial systems tend to perform well because, in general, the active ingredient components and the carrier systems have been well developed and proved out in prior testing. The test retentions were also easy to specify because of an extensive data base or existence of a widely accepted commercial ground-contact loading (e.g. CCA in pine at 6.4 kg/m^3). The oil-borne systems have the additional oil component which contributes to the preservative efficacy of the system. In contrast, the PRP/Pyr and RH287 systems have the disadvantages of having relatively little formulation development for ground-contact pressure treatment applications (especially in hardwoods) and relatively little information to use in determining the appropriate retentions to evaluate in this work.

Results from termite testing are not shown here. The ratings for almost all treated test replicates are high, allowing little distinction between systems. This is because only a single retention was tested and this was set at the conservative commercial ground contact loading. In this exposure, there is little leaching hazard or weathering of the installed specimens, so they should be expected to perform well in the future. The purpose of this section of the work was to complement the field stake testing where there is little termite pressure at that site, and make sure there were no obvious termite problems with a given system/species combination.

CONCLUSION

This paper summarizes current results from soil bed and field stake evaluations of eleven wood preservative systems - ACQ Type B, Copper Citrate 2:1, CDDC, chlorothalonil/ chlorpyrifos, copper-8-quinolinolate, tebuconazole/chlorpyrifos, RH287, propiconazole/ chlorpyrifos, copper naphthenate, CCAand creosote - in seven North American wood species. The more highly developed commercial systems and those in an oil carrier tend to perform the best. In a number of cases, however, there is a strong wood species effect where the systems tend to perform better in the softwoods and red oak, compared to the lower density hardwoods.

REFERENCES

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Table 2. Results from field stakes (16 months exposure in Hawaii, decay and termite ratings) and soil bed stakes (27 months of exposure, decay ratings only).

			Field Stakes[1]		Soil Bed[1] (Months Exposure)				
Treatment	Target Ret'n	Wood Species	Decay	Termite	3	9	15	21	27
	- kg/m³ -								
ACQ	1.6	Southern Pine	10	10					
		Red Oak	9.0	9.9					
		Yellow Poplar	8.7	9.8					
		Cottonwood	9.4	10					
	3.2	Southern Pine	9.9	10					
		Oak	9.3	10					
		Yellow Poplar	9.5	10					
		Cottonwood	9.4	10					
	6.4	Southern Pine	10	10	10	10	10	9.8	9.1
		Oak	9.5	10	10	9.9	9.4	9.0	8.1
		Yellow Poplar	10	10	10	10	9.7	9.7	8.9
		Cottonwood	10	10	10	9.9	9.6	9.5	8.6
		Eastern Hemlock	10	10					
		Red Maple	10	10					
		Sweetgum	10	10					
	12.8	Southern Pine	10	10					
		Oak	10	10					
		Yellow Poplar	10	9.5					
		Cottonwood	10	10					
CC	6.4	Southern Pine	10	10	10	10	10	10	8.8
		Oak	9.6	10	10	10	9.9	9.5	8.2
		Yellow Poplar	10	10	10	9.9	9.6	9.7	8.6
		Cottonwood	10	10	10	10	9.8	9.3	8.5
		Eastern Hemlock	10	10					
		Red Maple	10	10					
		Sweetgum	10	10					
	9.6	Southern Pine	10	10					
		Oak	10	10					
		Yellow Poplar	9.9	10					
		Cottonwood	10	10					
	12.8	Southern Pine	10	10					
		Oak	10	10					
		Yellow Poplar	10	10					
		Cottonwood	9.9	10					
	16.0	Southern Pine	10	10					
		Oak	9.9	10					
		Yellow Poplar	10	10					
		Cottonwood	10	10					

Table 1. Continued

Treatment	Target Ret'n	Wood Species	Field Stakes[1]		Soil Bed[1] (Months Exposure)				
			Decay	Termite	3	9	15	21	27
	- kg/m³ -								
CDDC	4.6	Southern Pine	10	10					
		Red Oak	8.7	9.7					
		Yellow Poplar	7.7	9.3					
		Cottonwood	7.9	9.7					
	9.3	Southern Pine	10	10					
		Red Oak	8.9	9.9					
		Yellow Poplar	8.9	10					
		Cottonwood	8.2	10					
	18.6	Southern Pine	10	10	10	10	9.8	8.4	7.7
		Red Oak	9.2	10	10	9.7	8.4	6.8	6.1
		Yellow Poplar	8.5	9.3	10	9.1	7.9	6.1	6.3
		Cottonwood	7.8	9.6	10	9.5	8.6	6.8	6.2
		Eastern Hemlock	10	10					
		Red Maple	8.6	9.8					
		Sweetgum	8.9	9.9					
	27.8	Southern Pine	10	10					
		Red Oak	9.2	9.9					
		Yellow Poplar	8.8	9.9					
		Cottonwood	8.4	9.9					
Cu-8	1.3	Southern Pine	9.8	9.8					
		Red Oak	9.2	9.3					
		Yellow Poplar	8.8	9.1					
		Cottonwood	8.4	9.5					
	2.4	Southern Pine	10	10					
		Red Oak	9.8	9.9					
		Yellow Poplar	9.6	9.6					
		Cottonwood	9.8	10					
	4.8	Southern Pine	10	10	10	10	9.9	8.9	8.7
		Red Oak	10	10	10	10	9.8	8.4	8.0
		Yellow Poplar	10	10	10	10	10	8.9	8.8
		Cottonwood	9.3	10	10	10	10	8.5	8.6
		Eastern Hemlock	10	10					
		Red Maple	10	10					
		Sweetgum	9.7	10					
	9.6	Southern Pine	10	10					
		Red Oak	10	10					
		Yellow Poplar	10	10					
		Cottonwood	10	10					

Table 1. Continued.

Treatment	Target Ret'n	Wood Species	Field Stakes[1] Decay	Field Stakes[1] Termite	Soil Bed[1] (Months Exposure) 3	9	15	21	27
	- kg/m^3 -								
Teb/CPF[2]	0.24/0.28	Southern Pine	9.6	10					
		Red Oak	9.2	10					
		Yellow Poplar	8.2	9.9					
		Cottonwood	7.7	9.2					
	0.48/0.28	Southern Pine	9.9	9.9					
		Red Oak	9.2	10					
		Yellow Poplar	8.7	9.6					
		Cottonwood	7.7	9.8					
	0.96/0.28	Southern Pine	9.4	10	10	10	9.1	8.4	7.7
		Red Oak	9.2	10	10	10	9.1	8.6	7.8
		Yellow Poplar	8.2	9.9	10	9.9	8.9	7.8	7.4
		Cottonwood	7.9	9.9	10	9.5	8.8	7.9	7.2
		Eastern Hemlock	10	10					
		Red Maple	8.9	10					
		Sweetgum	8.8	9.5					
	1.92/0.28	Southern Pine	9.4	10					
		Red Oak	9.2	10					
		Yellow Poplar	8.8	10					
		Cottonwood	9.0	10					
RH 287	0.24	Southern Pine	8.7	9.2					
		Red Oak	8.1	9.0					
		Yellow Poplar	5.2	8.5					
		Cottonwood	5.8	8.6					
	0.48	Southern Pine	9.8	10					
		Red Oak	7.8	9.9					
		Yellow Poplar	5.3	7.9					
		Cottonwood	3.7	7.6					
	0.96	Southern Pine	9.5	10	10	9.5	8.7	8.0	6.8
		Red Oak	8.8	9.6	10	9.2	8.3	7.0	4.3
		Yellow Poplar	4.7	9.3	10	5.9	1.2	0.7	0.0
		Cottonwood	4.6	8.4	10	7.8	3.7	2.2	0.2
		Eastern Hemlock	10	10					
		Red Maple	8.7	8.9					
		Seetgum	6.7	8.3					
	1.92	Southern Pine	10	10					
		Red Oak	9.7	9.6					
		Yellow Poplar	8.1	8.7					
		Cottonwood	2.2	7.3					

Table 2. Continued.

Treatment	Target Ret'n	Wood Species	Field Stakes[1]		Soil Bed[1] (Months Exposure)				
			Decay	Termite	3	9	15	21	27
	- kg/m³ -								
PRP/Pyr	0.24/0.48	Southern Pine	9.0	9.8					
		Red Oak	8.9	9.9					
		Yellow Poplar	4.4	8.7					
		Cottonwood	7.0	9.6					
	0.48/0.48	Southern Pine	9.1	9.8					
		Red Oak	8.5	9.8					
		Yellow Poplar	7.3	8.8					
		Cottonwood	5.8	9.0					
	0.96/0.48	Southern Pine	9.3	9.6	10	9.0	8.7	8.6	7.4
		Red Oak	8.6	9.8	10	8.7	8.4	7.7	6.8
		Yellow Poplar	7.0	7.7	10	8.0	6.5	3.6	1.3
		Cottonwood	6.7	8.7	10	7.9	5.3	3.8	0.0
		Eastern Hemlock	9.9	10					
		Red Maple	7.6	9.4					
		Sweetgum	8.0	8.1					
	1.92/0.48	Southern Pine	9.5	9.9					
		Red Oak	9.0	9.2					
		Yellow Poplar	8.1	9.6					
		Cottonwood	3.9	8.9					
CTL/CPF[2]	1.6/0.28	Southern Pine	10	10					
		Red Oak	9.1	9.9					
		Yellow Poplar	9.0	10					
		Cottonwood	8.6	9.5					
	3.2/0.28	Southern Pine	10	10					
		Red Oak	8.2	9.8					
		Yellow Poplar	8.7	10					
		Cottonwood	8.6	9.8					
	4.8/0.28	Southern Pine	10	10	10	10	9.5	8.7	7.9
		Red Oak	9.5	10	10	10	9.2	9.0	8.0
		Yellow Poplar	9.6	10	10	9.4	9.0	8.3	6.0
		Cottonwood	9.8	10	10	9.4	9.1	7.6	6.5
		Eastern Hemlock	10	10					
		Red Maple	9.2	10					
		Sweetgum	9.1	9.8					
	6.4/0.28	Southern Pine	10	10					
		Red Oak	9.3	10					
		Yellow Poplar	9.5	10					
		Cottonwood	9.7	9.9					

Table 2. Continued

Treatment	Target Ret'n	Wood Species	Field Stakes[1] Decay	Field Stakes[1] Termite	Soil Bed[1] (Months Exposure) 3	9	15	21	27
	- kg/m³ -								
CuNap	0.24[3]	Southern Pine	10	10					
		Red Oak	9.4	10					
		Yellow Poplar	8.9	10					
		Cottonwood	9.0	9.9					
	0.48[3]	Southern Pine	10	10					
		Red Oak	9.7	10					
		Yellow Poplar	9.7	10					
		Cottonwood	9.8	9.8					
	0.96[3]	Southern Pine	10	10	10	10		9.2	8.5
		Red Oak	10	10	10	10		9.3	8.6
		Yellow Poplar	9.9	10	10	10		9.1	8.5
		Cottonwood	9.1	10	10	10		9.1	8.5
		Eastern Hemlock	10	10					
		Red Maple	10	10					
		Sweetgum	9.5	10					
	1.92[3]	Southern Pine	10	10					
		Red Oak	10	10					
		Yellow Poplar	10	10					
		Cottonwood	10	10					
CCA	1.6	Southern Pine	10	10					
		Red Oak	9.0	10					
		Yellow Poplar	7.6	8.2					
		Cottonwood	7.3	9.5					
	3.2	Southern Pine	10	10					
		Red Oak	9.1	10					
		Yellow Poplar	8.4	9.4					
		Cottonwood	9.0	10					
	6.4	Southern Pine	10	10	10	10	10	10	9.2
		Red Oak	10	10	10	10	9.4	8.5	7.5
		Yellow Poplar	9.5	10	10	9.8	8.1	5.8	4.2
		Cottonwood	9.8	10	10	9.6	8.5	6.7	5.3
		Eastern Hemlock	10	10					
		Red Maple	9.4	10					
		Sweetgum	9.4	10					
	12.8	Southern Pine	10	10					
		Red Oak	10	10					
		Yellow Poplar	10	10					
		Cottonwood	10	10					

Table 2. Continued.

Treatment	Target Ret'n	Wood Species	Field Stakes[1]		Soil Bed[1] (Months Exposure)				
			Decay	Termite	3	9	15	21	27
	- kg/m³ -								
Creosote	40	Southern Pine	9.6	10					
		Red Oak	9.9	10					
		Yellow Poplar	8.4	9.9					
		Cottonwood	8.1	8.9					
	80	Southern Pine	10	10					
		Red Oak	9.9	10					
		Yellow Poplar	9.1	9.8					
		Cottonwood	8.8	9.9					
	160	Southern Pine	10	10	10	10		9.7	9.2
		Red Oak	10	10	10	10		9.9	9.3
		Yellow Poplar	8.7	10	10	10		9.2	8.9
		Cottonwood	9.4	10	10	10		9.6	8.6
		Eastern Hemlock	10	10					
		Red Maple	10	10					
		Sweetgum	9.9	10					
	320	Southern Pine	10	9.0					
		Red Oak	10	10					
		Yellow Poplar	10	10					
		Cottonwood	9.8	10					
Untreated	----	Southern Pine	6.4	8.8	10	8.4	6.4	6.4	4.0
		Red Oak	7.2	8.5	10	8.6	6.3	5.5	2.3
		Yellow Poplar	2.4	7.7	8.7	3.8	0.8	0.0	--
		Cottonwood	0.7	7.5	9.0	4.0	0.8	0.7	0.0
		Eastern Hemlock	6.1	9.6					
		Red Maple	2.9	8.0					
		Sweetgum	3.8	7.9					

[1] Average ratings of 20 stakes; AWPA E7, 7 point rating system; 10 - sound, 0 - failure.
[2] P9 oil retention = 7.0 pcf.
[3] Retention of Copper only.