B. Performance of Water Diffusible Preservatives as Internal Treatments

While fumigants have long been an important tool for utilities seeking to prolong the service lives of wood poles and limit the extent of internal decay, some users have expressed concern about the risk of these chemicals. Water diffusible preservatives such as boron and fluoride have been developed as potentially less toxic, more easily handled alternatives to fumigants.

Boron has a long history of use as an initial treatment of freshly sawn lumber to prevent infestations by various species of powder post beetles in both Europe and New Zealand. This chemical has also been used more recently for treatment of lumber in Hawaii to limit attack by the Formosan subterranean termite. Boron is attractive as a preservative because it has exceptionally low toxicity to non-target organisms, especially humans, and because it has the ability to diffuse through wet wood. In principle, a decaying utility pole should be wet, particularly near the groundline and this moisture can provide the vehicle for boron to move from the point of application to wherever decay is occurring. Boron is available for remedial treatments in a number of forms, but the most popular are fused borate rods which come as pure boron or boron plus copper. These rods are produced by heating boron to its molten state, then pouring the molten boron into a mold. The cooled boron rods are easily handled and applied. In theory, the boron is released as the rods come in contact with water.

Fluoride has also been used in a variety of preservative formulations going back to the 1930's when fluor-chrome-arsenic-phenol was employed as an initial treatment. Fluoride, in rod form, has long been used to treat the area under tie plates in railroad tracks and has been used as a dip-diffusion treatment in Europe. Fluoride can be corrosive to metals, although this should not be a problem in the groundline area. Sodium fluoride can also be formed into rods for application, although the rods are less dense than the boron rods.

Both of these chemicals have been available for remedial treatments for several decades, but widespread use of these systems has only occurred in the last decade and most of this application has occurred in Europe. As a result, there is considerable performance data on boron and fluoride as remedial treatments on European species, but little data on performance on U.S. species used for utility poles.

1. Performance of Copper Amended Fused Boron Rods

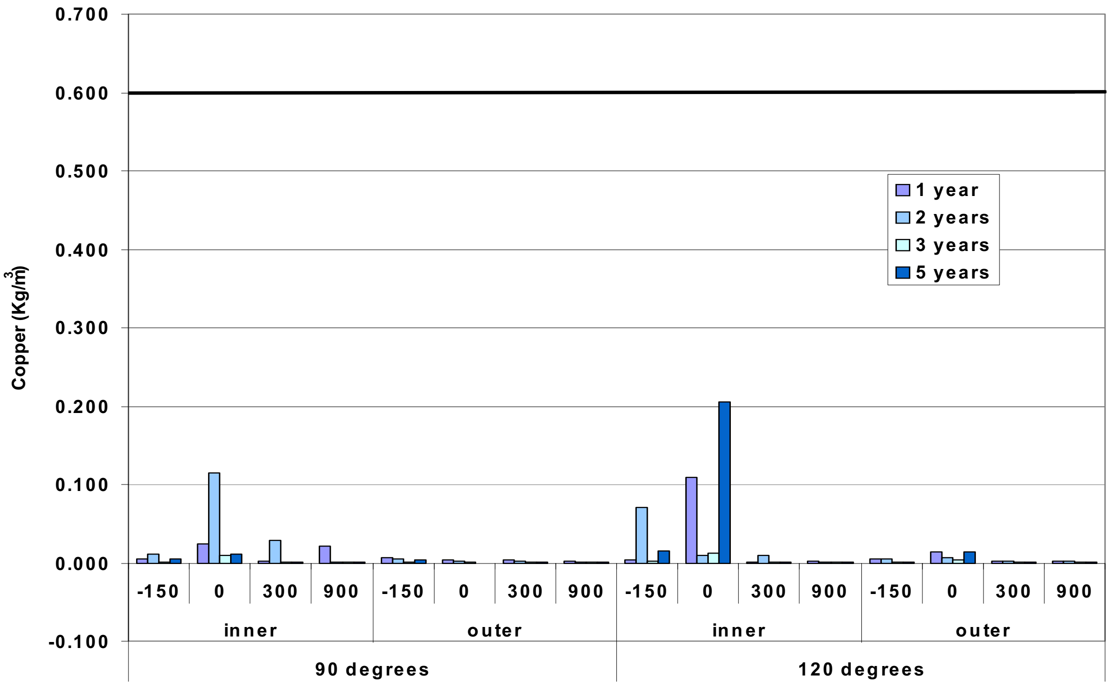
Date Established:	November 2001
Location:	Peavy Arboretum, Corvallis, OR
Pole Species, Treatment, Size	Douglas-fir, penta and Douglas-fir creosote
Circumference @ GL (avg., max., min.)	78, 101, 66 cm

The ability of boron and copper to move from fused rods was assessed by drilling holes perpendicular to the grain in pentachlorophenol treated Douglas-fir poles beginning at the groundline and then moving upward 150 mm and either 90 or 120 degrees around the pole. The poles were treated with either four or eight copper/boron rods or four boron rods. The holes were then plugged with tight fitting plastic plugs.

Chemical movement was assessed 1, 2, 3 and 5 years after treatment by removing increment cores from locations 150 mm below groundline as well as at groundline, and 300 or 900 mm above this zone. The outer, 25 mm of treated shell was discarded, and the core was divided into inner and outer halves. The cores from three poles at a given height and treatment were combined and then ground to pass a 20 mesh screen. The resulting sawdust was first analyzed for copper by x-ray fluorescence spectroscopy, and then extracted in hot water. The extract was analyzed for boron content using the azomethine-H method.

Copper levels in poles treated with four rods were slightly elevated at groundline in the inner zones of poles treated using both the 90 and 120 degree treating patterns 2 years after treatment, but even these levels were well below the threshold for wood protection (Figure I-13). Copper was barely detectable away from these zones.

a



b

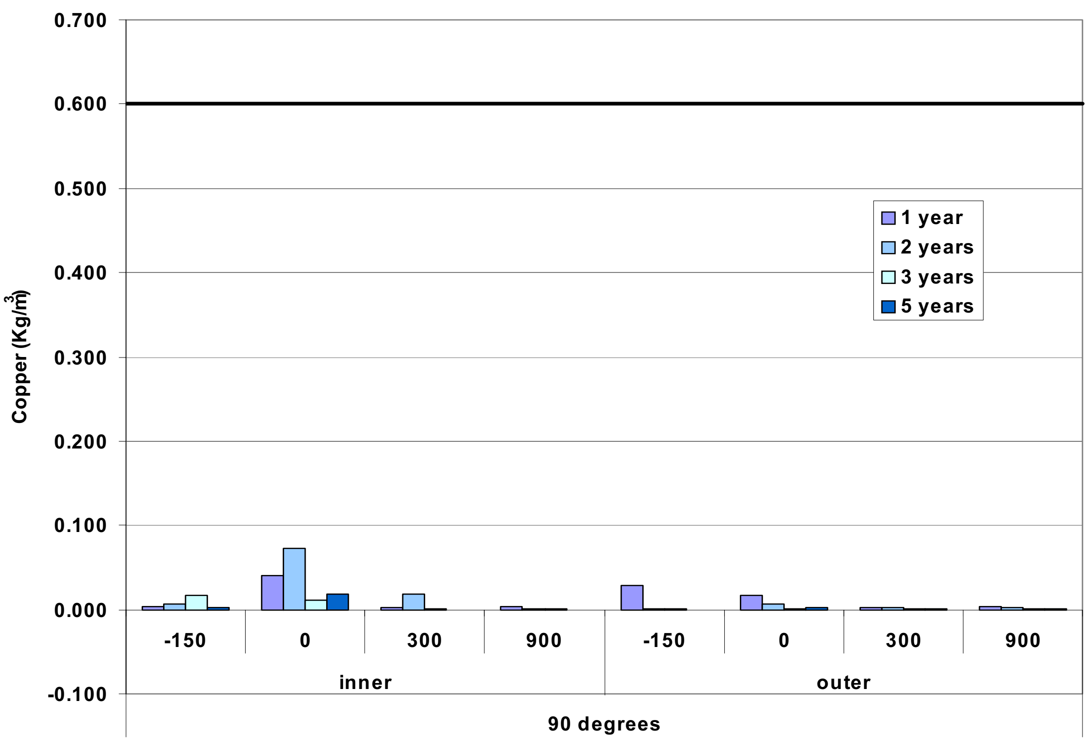


Figure I-13. Copper levels in increment cores removed from selected locations above and below the groundline in Douglas-fir pole sections 1 to 5 years after treatment with a) 4 or b) 8 copper/boron rods. The threshold for copper is 0.6 kg/m^3.

Copper levels in the eight-rod treatment tended to be lower than those found with the 4-rod treatment. While the lower levels appear to be counterintuitive, they are consistent with previous tests of water diffusible systems. In many cases, higher dosages appear to slow initial chemical movement, possibly as the rods sorb moisture from the surrounding wood, thereby reducing water available for diffusion to occur. In summary, copper does not appear to be moving from the rods at levels that would confer protection away from the original point of treatment.

Boron levels in the inner zones of poles receiving 4 copper/boron rods were above the threshold for internal protection at and below groundline 2 years after treatment regardless of hole orientation (Figure I-14). Levels in poles treated with the 90 degree spacing fell sharply, but were still at the lower boron threshold 3 years after treatment, while levels in the poles with the 120 degree hole spacing remained elevated.

Boron levels were at or slightly below the threshold 300 mm above groundline after 2 years, then declined to near background levels 3 years after treatment. Boron levels rose at the 5 year point, suggesting that boron continued to move out of the treatment holes and into the wood. Boron levels at groundline in both the 90 and 120 degree treatments were well above the threshold and much higher than at any previous time. It is unclear why boron levels increased so substantially at the 5 year point, but these results suggest that the boron was diffusing well from the rods at or below groundline, but faced challenges in the above ground zones. Boron levels in the outer zones tended to be lower, but were above the lower threshold at groundline 5 years after treatment.

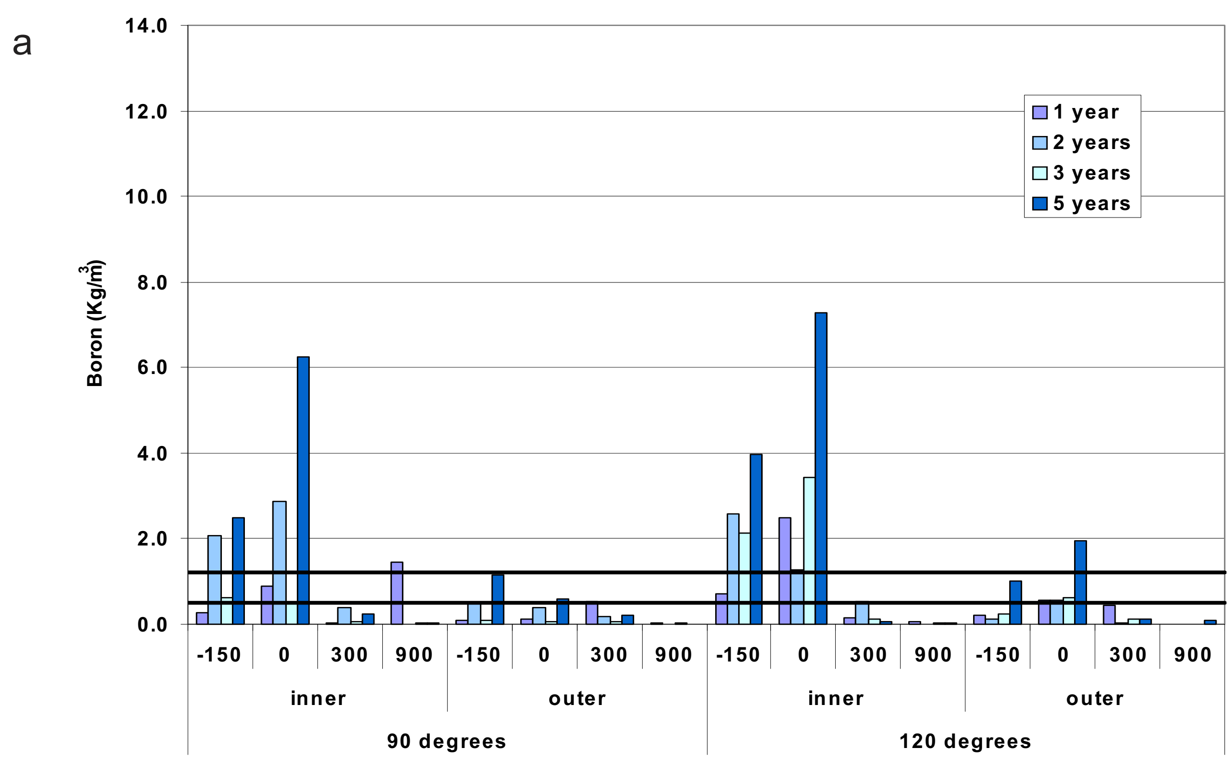
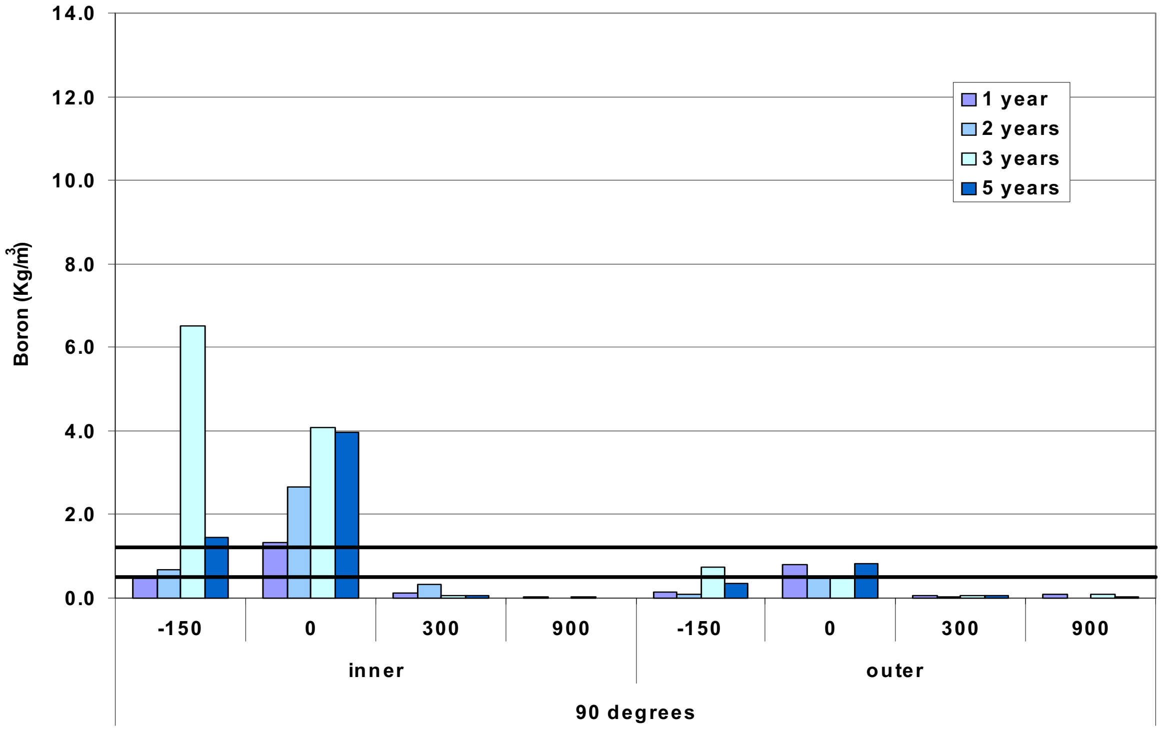


Figure I-14. Boron levels in increment cores removed from selected locations above and below the groundline in Douglas-fir pole sections 1 to 5 years after treatment with a) four copper/boron rods, b) eight copper/boron rods or c) four boron rods. Lower and upper boron threshold levels are 0.5 and 1.2 kg/m^3 boric acid equivalent (BAE).

b



c

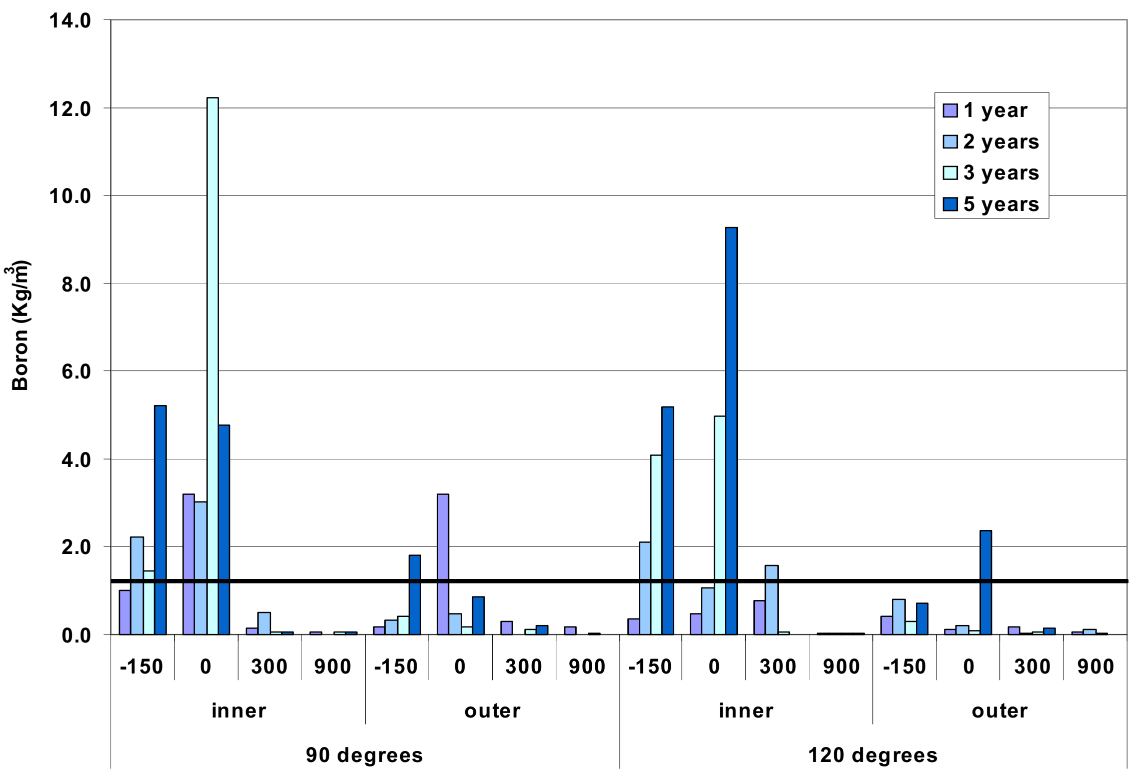


Figure I-14 (cont.). Boron levels in increment cores removed from selected locations above and below the groundline in Douglas-fir pole sections 1 to 5 years after treatment with a) four copper/boron rods, b) eight copper/boron rods or c) four boron rods. Lower and upper boron threshold levels are 0.5 and 1.2 kg/m^3 boric acid equivalent (BAE).

Boron levels in the poles treated with non-copper amended boron rods were sometimes slightly higher than those for the poles receiving copper/boron rods, but the differences appeared to be slight. Once again, the boron levels below groundline and at groundline were at or above the threshold. Although we did not measure the moisture contents of the poles in this test, in other field trials moisture contents in poles at groundline are well over 30% and the cone of moisture extends upward a meter or so during our wet winter months. The results indicate that the boron from the rods is moving within the groundline zone where moisture is adequate for diffusion to occur.

Boron levels in poles treated with 8 copper/boron rods tended to be lower than those found with the 4-rod treatment over the 5 year test, again suggesting that excessive chemical in the hole retards initial boron distribution. As a result, more chemical may not necessarily be the best approach for rapid decay control when these systems are employed. Instead, supplemental moisture addition may be a more fruitful approach to enhance boron movement and more quickly arrest fungal attack. Since the installation of this test, some producers recommend adding a dilute boron solution to the treatment hole when installing rods . No supplement was added to the rods when this test was installed, but our previous tests indicate that this solution produces a long lasting boost to boron levels in the wood.

Cultural results of wood removed from the boron and copper/boron rod treated poles suggest that the poles are being invaded by a number of non-decay fungi at or near groundline. These fungi do not cause degradation of the wood structure, but they can condition the wood and allow other fungi to colonize the substrate.

Basidiomycete isolations are still low at most locations, however, the levels have risen in the boron rod treated poles, both at groundline and 900 mm above that zone (Table I-7). Decay fungi were also isolated from the upper height in the poles receiving 4 boron/copper rods, but decay fungi were only isolated

Table I-7. Isolation frequency of decay and non decay fungi from Douglas-fir pole sections 1 to 5 years after treatment with boron or copper/boron rods in two different spacing patterns.

Treatment	Rod Spacing	Year Sampled	Isolation Frequency (%)[a]			
			-150 mm	0 mm	300 mm	900 mm
4 copper/boron rods	90°	1	0^{7}	0^{10}	0^{20}	0^{7}
		2	0^{33}	0^{20}	0^{10}	7^{0}
		3	0^{27}	0^{10}	0^{0}	7^{13}
		5	0^{33}	0^{30}	20^{0}	7^{13}
4 copper/boron rods	120°	1	0^{40}	0^{0}	0^{0}	0^{13}
		2	0^{33}	0^{20}	0^{0}	0^{0}
		3	0^{47}	0^{30}	0^{0}	7^{7}
		5	0^{40}	0^{10}	0^{10}	0^{0}
4 boron rods	90°	1	0^{7}	0^{10}	0^{0}	0^{0}
		2	0^{20}	10^{10}	0^{0}	7^{0}
		3	0^{40}	10^{50}	0^{0}	13^{7}
		5	7^{27}	10^{20}	10^{0}	13^{0}
4 boron rods	120°	1	0^{0}	0^{0}	0^{0}	0^{20}
		2	0^{20}	10^{10}	0^{0}	7^{0}
		3	0^{40}	10^{50}	0^{0}	13^{7}
		5	0^{47}	10^{30}	0^{10}	7^{0}
8 copper/boron rods	90°	1	0^{0}	0^{0}	0^{0}	0^{7}
		2	0^{0}	0^{0}	0^{20}	0^{7}
		3	0^{27}	0^{10}	0^{0}	0^{0}
		5	0^{33}	0^{0}	0^{0}	13^{33}

[a]Values represent means of fifteen cultures per treatment. Superscripts denote non-decay fungi.

900 mm above groundline in the poles receiving 8 rods. The gradual increase in fungal isolations from the poles is not surprising given the relatively low levels of boron present. Clearly, these isolation levels remain low, but will need to be monitored over the next few years to determine if the treatments can provide any protection to the poles.

Decay fungi were isolated from positions in poles for which the average residual boron is well above threshold (for example, 4 boron rods at 120 degrees at groundline at 3 and 5 years). Although the wood for chemical analysis and culturing comes from the same increment cores, the data cannot be matched on an individual basis because wood from three poles and two or three sampling heights (six or nine cores depending on sampling height) was combined to provide sufficient wood for analysis. It is likely, especially at groundline, that some cores are much closer to the rods than others.

2. Performance of Fused Borate Rods in Internal Groundline Treatments of Douglas-fir Poles

Date Established:	May 1993
Location:	Peavy Arboretum, Corvallis, OR
Pole Species, Treatment, Size	Douglas-fir, penta
Circumference @ GL (avg., max., min.)	100, 114, 89 cm

Thirty pentachlorophenol treated Douglas-fir poles (283-364 mm in diameter by 2 m long) were set to a depth of 0.6 m at the Peavy Arboretum test site. Three 19 mm diameter by 200 mm long holes were drilled perpendicular to the grain beginning at groundline and moving around the pole 120 degrees and upward 15 cm. Each hole received either one or two boron rods (180 or 360 g of rod, respectively). The holes were then plugged with tight fitting wood dowels. Each treatment was replicated on ten poles.

The poles were sampled 1, 3, 4, 5, 7, 10, and 12 years after treatment by removing increment cores from sites located 15 cm below groundline as well as 7.5, 22.5, 45, and 60 cm above the groundline. Boron levels above the toxic threshold were detected 12 years after treatment. These poles will next be inspected in 2008, 15 years after treatment.

3. Effect of Glycol on Movement of Boron from Fused Borate Rods

Date Established:	March 1995
Location:	Peavy Arboretum, Corvallis, OR
Pole Species, Treatment, Size	Douglas-fir, penta
Circumference @ GL (avg., max., min.)	87, 99, 81 cm

While boron has been found to move with moisture through most pole species (Dickinson et al., 1988; Dietz and Schmidt, 1988; Dirol, 1988; Edlund et al., 1983; Ruddick and Kundzewicz, 1992), our initial field tests showed slower movement in the first year after application. One remedy to the slow movement that has been used in Europe has been the addition of glycol. Glycol is believed to stimulate movement through dry wood that would normally not support diffusion (Bech-Anderson, 1987; Edlund et al., 1983).

Pentachlorophenol treated Douglas-fir pole sections (259 to 315 mm in diameter by 2.1 m long) were set to a depth of 0.6 m in the ground at the Peavy Arboretum test site. The pole test site receives an average yearly precipitation of 1050 mm with 81% falling between October and March.

Four 19 mm diameter holes were drilled at a 45 ^{o} downward sloping angle in each pole, beginning 75 mm above the groundline, then moving 90 degrees around and up to 230, 300, and 450 mm above the