United States
Department of
Agriculture

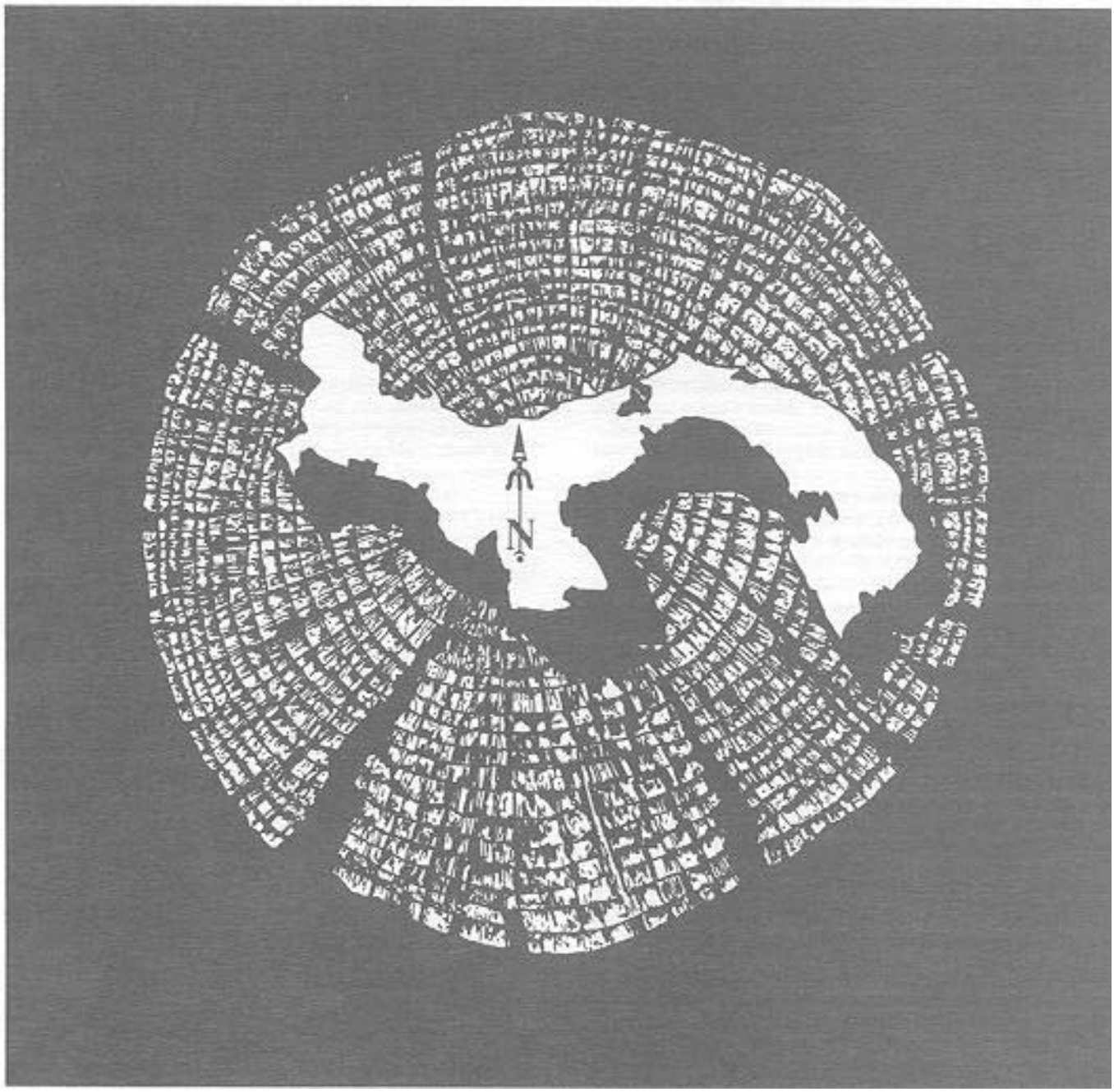
Forest Service

Forest
Products
Laboratory

Research
Paper
FPL-RP-478

Durability of Utility Poles in Panama

Rodney C. DeGroot



Abstract

Creosote-treated southern pine and Douglas-fir utility poles produced in the United States and installed in Panama were inspected for termites and for decay at the groundline. Findings indicate that current U.S. industrial and federal specifications for creosote treatment of southern pine poles provide adequate protection in most tropical environments, but some variation in performanck was observed between poles set in different ecological biomes. In tropical regions, such as Panama, where termites pose a serious hazard, specifications for creosote treatment of Douglas-fir poles should be supplemented with requirements for treatment of soil around the pole with an approved termiticide.

Keywords: Preservative, creosote, poles, pine, Douglas-fir, termites, Tropics, decay.

August 1986

DeGroot, Rodney C. Durability of utility poles in Panama. Res. Pap. FPL-RP-478. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory; 1986. 12 p.

The use of trade, firm, or corporation names in this publication is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by the U.S. Department of Agriculture of any product or service to the exclusion of others that may be suitable.

This publication reports research involving pesticides. It does not contain recommendations for their use, nor does it imply that the uses discussed here have been registered. All uses of pesticides must be registered by appropriate State and/or Federal agencies before they can be recommended.

A limited number of free copies of this publication are available to the public from the Forest Products Laboratory, One Gifford Pinchot Drive, Madison, WI 53705-2398. Laboratory publications are sent to over 1,000 libraries in the United States and elsewhere.

The Laboratory is maintained in cooperation with the University of Wisconsin.

Contents

	Page
Introduction	1
Literature	1
Methods	2
Southern Pine Poles	2
First Line	2
Second Line	3
Other Southern Pine Inspections	4
Douglas-fir Poles	4
Results	5
Southern Pine Poles	5
Douglas-fir Poles	8
Discussion	10
Conclusions	11
Literature Cited	11

Durability of Utility Poles in Panama[1]

Rodney C. DeGroot, Plant Pathologist
Forest Products Laboratory, Madison, WI

Introduction

Because of the long life expectancy of utility poles, timely reviews of pole performance in the field are useful in ascertaining whether the minimum requirements of existing wood preservation standards provide adequate protection. This is particularly true for poles used in the Tropics where the potential for biological attack is greater than that experienced in temperate climates. To develop a data base on the durability of poles produced in the United States and used in the Tropics, the author is making case studies of poles for which some information on procurement specifications and history is available.

[1]This study was partially supported by the U.S. Army under interagency cooperative agreement FP-80-0292. The assistance of personnel in local engineering offices in Panama and in the Corps of Engineers Office at Mobile, AL, is gratefully acknowledged. Specialists at the Forest Products Laboratory who contributed to this study are Donna Christensen, wood identification; Daniel Foster, preservative analysis: and Thomas Kuster, scanning electron microscope examinations.

Literature

Little information is available on the durability of U.S.-produced poles installed in the Tropics. Boone (1965) concluded from examination of records for utility poles on the island of Hawaii that neither rainfall nor differences in elevation had any effect on the durability of pressure-treated Douglas-fir and southern pine poles. Boone presumed treated poles were to have been pressure treated with creosote to a retention of 8 pounds per cubic foot (128 kg/m^3). In urban areas with 130-200 inches (3,302-5,080 mm) annual rainfall, both treated species declined at about the same rate. After 20 years, 75 percent of the Douglas-fir poles and 73 percent of the southern pine poles remained serviceable. And after 25 years, Douglas-fir averaged 58 percent serviceable and southern pine 54 percent.

In rural areas, Boone found performance of pressure-treated Douglas-fir poles to be fairly consistent in all three lines studied. After 20 years, 89 percent of the poles remained serviceable. Records of pole durability for two lines of southern pine poles, however, were not comparable. One line of 161 poles showed 91 percent serviceable after 15 years and 90 percent after 20 years. The other line of 56 poles in a similar rainfall area showed only 68 percent serviceable after 15 years, 59 percent after 20 years, and 39 percent after 25 years of service.

Previous inspections of treated utility poles in Guam (DeGroot and Lauret 1986) suggest that Formosan termites can destroy the untreated heartwood core of class 1-5, creosote-treated, Douglas-fir poles, but this attack can be prevented by treating soil around the poles with an approved termiticide.

Methods

Several lines of Douglas-fir poles and two lines of southern pine poles were examined in Panama. The histories of these lines were developed with the assistance of U.S. Army engineers in Panama and the U.S. Army Corps of Engineers Office, Mobile, AL. The exact specifications that were used during the procurement of poles for these lines could not be identified. It seems reasonable, however, to assume that individual procurements were required to meet preservation standards of the American Wood-Preservers' Association (AWPA) or an applicable issue of Federal Specification TT-W-571 (U.S. Federal Supply Service 1974). If poles were procured through the Defense Commodity Supply Command (DCSC), Federal specifications would have been used. For specific projects, poles could have been procured using guide specifications prepared by the Corps of Engineers, which, for treated wood products, reference only AWPA standards.

Five other creosote-treated southern pine poles with unknown procurement histories, except for information given on pole brands, were also examined.

All lines were located in an area formerly included in the Canal Zone. The soils there are predominantly residual soils, formed mostly from weathering of igneous rocks (basaltic, andesitic, rhyolitic in nature) and some sedimentary rocks (limestone, sandstone, shales, tufts). The extreme weathering in the humid tropical climate has produced lateritic soils that have a low ratio of silica to iron and alumina. The low silica ratio makes these soils highly friable, porous, and resistant to erosion. The principal soil groups in this zone are classified as Arraijan, Gatun, and Frijoles, and as silty clay. These soil groups usually have a brownish-red surface clay layer which is high in organic content, blocky in structure, and friable when moist (U.S. Army Tropical Test Center 1979).

Southern Pine Poles

First Line—Two lines of southern pine poles were inspected in December 1983. One line was located near Panama City about 10 miles (16.1 km) from the Pacific Ocean. It was constructed in a residential area during 1964-65. At that location, average annual rainfall is approximately 85 inches (2,159 mm). Average annual temperature is approximately 85 °F (29.4 °C). Natural biome type for that location, following a scheme proposed by Whittaker (1975), would be tropical seasonal forest. Parent material for soil is Tuff, agglomerate (U.S. Army Tropical Test Center 1979).

Twenty-four poles (a 20 pct sample) were randomly selected from this line and inspected for decay and termite attack. For this inspection, soil was removed from around each pole to a depth of 18 inches. The surface of the pole was carefully examined for presence of decay or termite attack. The equivalent reduction of pole circumference resulting from internal and external decay was estimated following published tables by the Rural Electrification Administration (1974). These reductions tacitly assume a more definitive boundary between sound and decayed wood than probably occurs. Therefore, estimates of reduction in circumference resulting from decay were categorized as being 1-10 percent, >10-20 percent, and >20 percent.

The condition of the pole, with regard to decay, was categorized as

A - no evidence of wood decay or soft rot

B - wood soft, soft rot or decay suspected

C - wood decay definitely present, but in small quantity. Structural performance of poles probably is not affected

D - sufficient wood decay present to cause 1-10 percent effective loss in pole circumference

E - sufficient wood decay present to cause >10-20 percent effective loss in pole circumference

F - sufficient wood decay is present to cause >20 percent reduction in pole circumference. Some poles may be severely decayed and should be removed.

Poles rated "B" for presence of soft rot or suspicion of decay oftentimes had only a film of soft wood on the surface of wood below grade. Nevertheless, examining samples of this soft wood from several poles verified that the softness was caused by degradation of cell walls and that Fungi Imperfecti were present (fig. 1). Wood collected from areas with advanced decay showed an abundance of bore holes and hyphae within tracheid cell walls (fig. 2).

Termite attack was not given a gradient of ratings, but poles were noted as being either solid or hollow when sounded with a hammer. Sounding detects only gross internal deterioration so decay or termite damage could be inside poles that sound solid. In addition, the presence or absence of active termite colonies was noted.

One increment core was taken at or near ground level from each of the poles inspected. Increment borings were made at locations without surface decay. Consequently ail measurements on increment cores are referenced to the original perimeter of the poles. Depths of preservative penetration and sound wood were determined directly on those cores. The cores were collated into two sequential groups of 10 each and analyzed for creosote retention 0.5-0.2 inch (1.3-5.1 cm) from the pole surface, i.e., the assay zone specified for southern pine in AWPA Standard C4 (AWPA 1983).

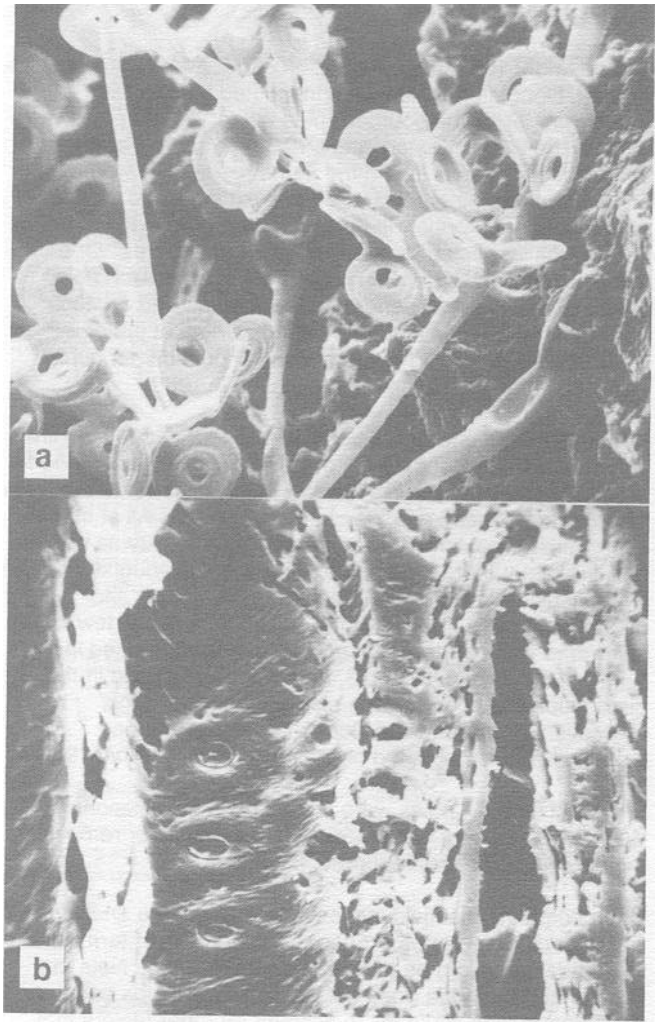


Figure 1.—SEM photographs (at 1000x) of (a) degraded tracheid cell walls and (b) conidia in soft rotted wood scraped from surface of creosote-treated southern pine pole. (MC84 9073)

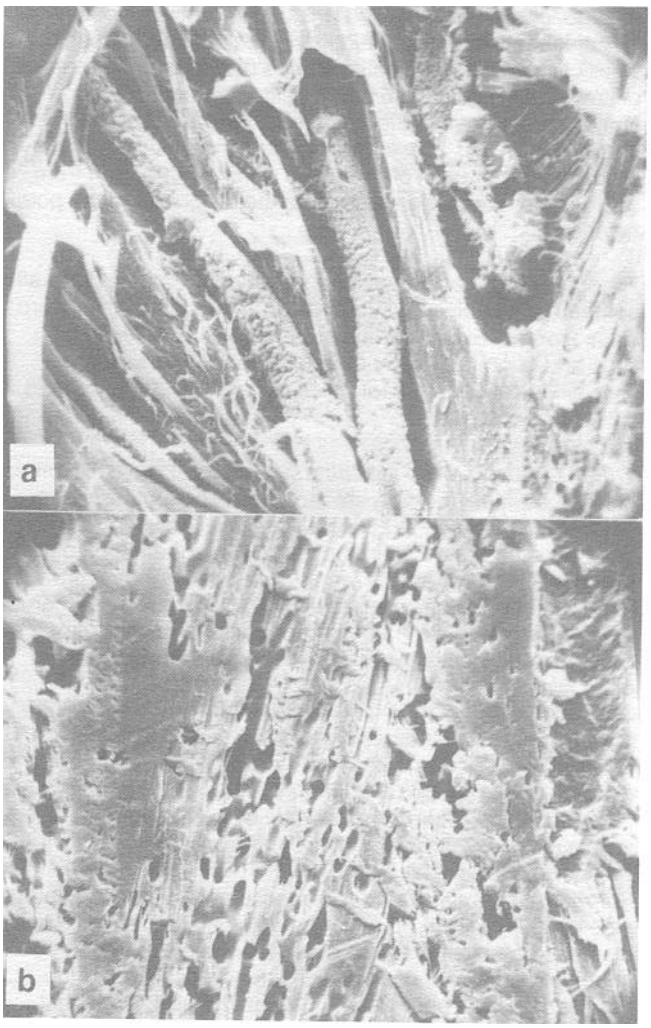


Figure 2.—Long sections of wood from a decay pocket at the base of a creosote-treated southern pine pole. (a) Radial section of tracheid cell walls showing abundance of cavities and bore holes in cell walls (2000x). (b) Hyphae within cell walls (5000x). (MC84 9074)

Second Line-The second line of southern pine poles was near Colon, on the Atlantic side of Panama. Average annual rainfall there is approximately 130 inches(3,302 mm). Ambient temperature ranges from 75 °F to 86 °F (24-30 °C). Natural biome-type for this location is tropical rain forest (Whittaker 1975). Parent material for soil at this site is Gatun formation (U.S. Army Tropical Test Center 1979).

The line near Colon was also constructed in 1964-65, but as with the other line, the exact installation date could not be determined. Most poles were removed in 1983. With 27 poles, however, the top halves were cut off, and the lower halves were left in place to support a telephone cable. Those remaining pole stubs were examined in consecutive order, except where flowers or shrubbery had been planted around the pole. Poles in this line were inspected below grade as were southern pine poles in the line near Panama City. This line also had serviced a residential area.

In 1983, one increment core was taken from each of the first 18 poles that were inspected in the second line. These cores were collated into sequential groups of nine each for analysis of creosote retention. To better estimate retentions in individual poles with different durabilities, I returned to this line in April 1984. Five increment cores were taken at the groundline from each of two poles with no decay and from each of two other poles with decay below grade on the pole exterior.

Except for one class 5 pole in the line near Panama City, all southern pine poles in both of the forementioned lines were class 2 or 3.[2] Except for the class 5 pole, all poles in both lines had been treated by the same firm. Information on brands indicated that most poles originally were 40-50 feet (12.2-15.2 m) long.

Other Southern Pine Inspections—In April 1984, five other class 3, 45-foot (13.7 -m) creosote-treated; southern pine poles were inspected at a location within 1 mile (1.6 km) from the Pacific end of the Panama Canal. Information on pole brands indicated that they were treated in 1974 by a firm different than the one that treated the two lines of southern pine poles previously inspected. Additional details of procurement requirements and inspection procedures are unknown.

Average annual rainfall at this location is approximately 70 inches (1,778 mm). Ambient temperatures range from 64 °F to 90 °F (18-30 °C) during the year. Soil there is Catival clay-reddish-brown clay underlaid by light-red and reddish-yellow clay (U.S. Army Tropical Test Center 1979).

For more information on performance of lo-year-old southern pine poles that were pressure treated with creosote, I inspected a series of seven class 4, creosote-treated, southern pine poles used as light standards in the same residential area near Panama City as the utility lines that were surveyed. Information on pole brands indicated that these poles were 45 feet (13.7 m) long, were treated with creosote in 1975 to a retention of 12 pounds per cubic foot (192 kg/m^3), and were treated by yet a different firm than those which treated the other southern pine poles. Soil was excavated around all seven poles, and the bases of the poles were inspected for wood decay and termites. With three poles, three increment cores were taken approximately 120 degrees apart, at the groundline. Depth of creosote penetration was measured on the cores. These data were collated later to determine creosote retention in wood 0.5-2.0 inches from the surface of the poles.

[2]Class sizes of poles are described in REA Bulletin 44-2:345-1, Spec. No. DT-3C (Electric) PE-9 (Telecommunications), Jan. 1982, U.S. Department of Agriculture, Washington, DC.

Douglas-fir Poles

In December 1983, ten 40- to 45- foot (12.2-13.7 m), creosote-treated, Douglas-fir poles were inspected below grade in the same manner as the southern pine poles. These poles were also on the Pacific Ocean side of Panama (near Panama City) in a distribution line in the same residential area as the line of southern pine poles. Soil was excavated to a depth of 18 inches from around the poles, and the pole exterior, below grade, was inspected for wood decay and termites. One increment boring was taken at groundline from each pole. Depth of preservative penetration was measured on each core. Information on pole brands indicated that the poles were treated in 1968 to a retention of 10 pounds per cubic foot (160 kg/m^3). This line was installed in 1969.

In April 1984, one transmission fine and four distribution lines constructed with Douglas-fir poles were visually examined for presence of termites and sounded with a hammer to estimate whether the standing pole was solid or hollow. All of these lines were in the same location near Panama City as was the first line of southern pine poles. The lines of Douglas-fir poles were installed in 1969. Most poles (transmission and distribution) were 40-45 feet (12.2-13.7 m) long. A few were taller; one was shorter. Class 2 or 3 poles were used in the transmission line. Class 2, 3, or 4 poles were used in the distribution lines. One of the distribution lines in this inspection included the 10 Douglas-fir poles that had previously been inspected below grade in December 1983.

With each fine; all poles were inspected in succession. Where replacement poles occurred, the cause for removing the original poles was recorded, if known.

Upon completion of field inspections, Chi-square analyses were used to test for proportionate differences in termite incidence that might be associated with incising. Note that such analysis of data does not prove relationships because the comparisons could fail to account for other factors that also affect likelihood of termite attack (i.e. distribution pattern of termites, etc.).

Results

Southern Pine Poles

Decay seems to be more severe in the line of creosote-treated southern pine poles at the high-rainfall Colon site than in the line with comparable poles at the equally warm but less moist site near Panama City (fig. 3). Three of the randomly selected poles near Panama City were wrapped at the groundline with asphaltic paper. Whether this had been done by a resident of the area or was evidence of a groundline treatment could not be determined. Maintenance personnel had no records or personal knowledge of groundline treatments being applied to that line; however, they did report that one pole had been replaced because of biodeterioration. No groundline treatment had been applied to the poles near Colon.

The creosote retentions determined in composite samples of increment cores from poles in two lines of southern pine poles suggest that the original retentions in poles at both locations met specifications for creosote retentions.

Proximal major city	Composite sample size	Retention[3]	
	Number of poles	*lb/ft³*	*(kg/m³)*
Panama City	10	14.4	(230)
	10	9.7	(155)
Colon	9	13.0	(208)
	9	11.6	(186)

[3]Creosote analyses made of wood 05-2.0 inch from surface of pole in accordance with AWPA Standard Al. Sample size was restricted to only 5 increment borings per analysis.

Likewise, creosote retentions determined in composite samples of five increment cores taken from four southern pine poles with different amounts of deterioration in a line near Colon, Panama, suggested that those individual poles were adequately treated.

Decay class	Retention[3]	
	lb/ft³	*(kg/m³)*
D	10.9	(174)
C	10.1	(162)
A	15.5	(248)
A	9.2	(147)

Deep penetration of creosote into the sapwood occurred in poles at both locations (figs. 4 and 5). Thus, penetration requirements, as defined by current AWPA specifications for southern pine poles, were met with the original treatment.

No termite attack was found in the lines of southern pine poles inspected near Colon (Atlantic side) or near Panama City (Pacific side).

Both termites and decay were seen in the five creosote-treated southern pine poles treated in 1974 and installed near the Pacific end of the Panama Canal. Of the three poles that were excavated, one had only termites, one had only wood decay below grade, and the third had both wood decay below grade and termites. The two poles that were not excavated showed no evidence of termite attack or decay above ground and were sound to the hammer when struck above ground.

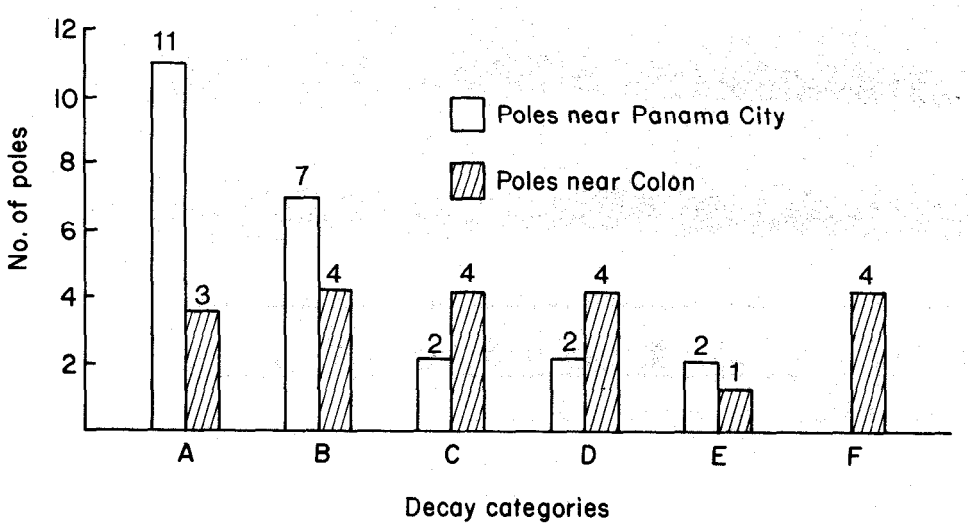


Figure 3.—Condition in 1983 of class 2 and 3, mostly 35-50 feet (12.2-15.2 m), creosote-treated, southern pine poles installed in Panama in 1964-65. Decay categories are described in the text. (MC84 9075)

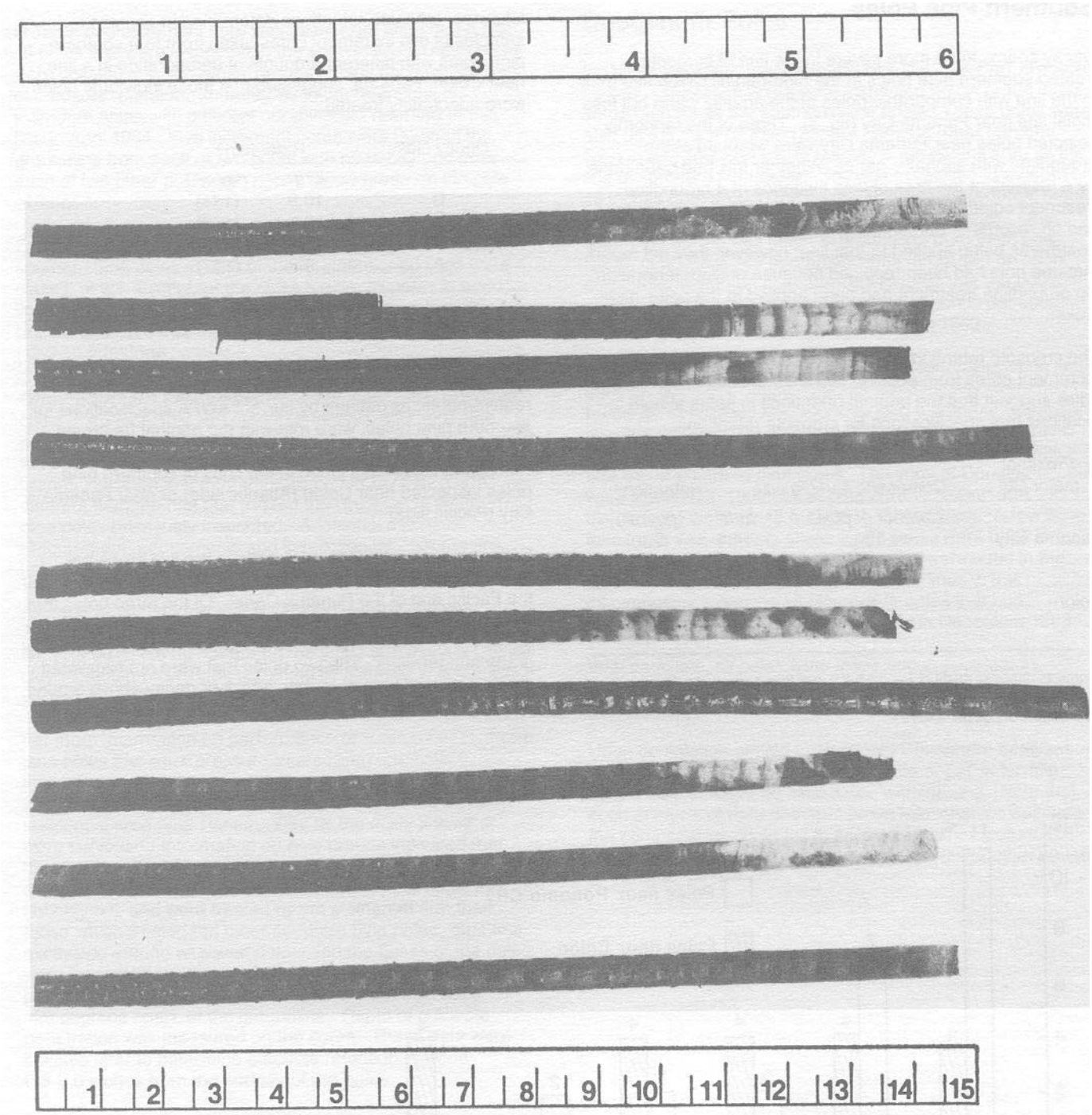


Figure 4.—Increment cores from stubs of creosote-treated southern pine poles remaining in line constructed near Colon in 1964-65. (M830 401)

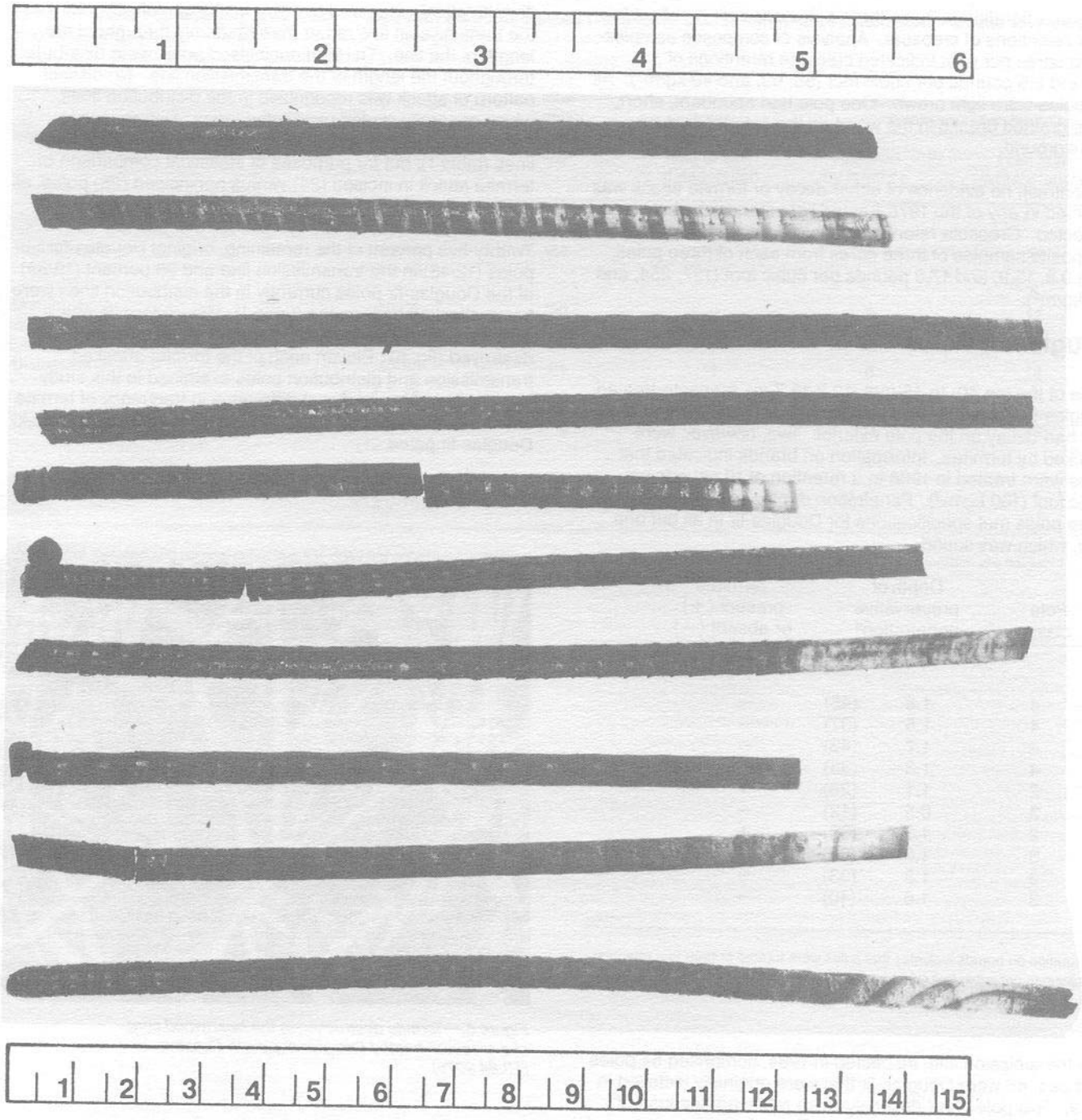


Figure 5.—Increment cores from creosote-treated southern pine poles in a line constructed near Panama City in 1964-65. (M830 402)

Early deterioration in these three poles appears to reflect low initial retentions of creosote. Analysis of composite samples of two cores per pole indicated creosote retentions of 3.5, 5.8, and 2.5 pounds per cubic foot (56, 93, and 40 kg/m^3). All five poles were light brown. One pole had abundant, short, cross-grained breaks in the wood on the exterior surface, above ground.

By contrast, no evidence of either decay or termite attack was detected in any of the 1975-treated light standards that were inspected. Creosote retentions, as determined from composite samples of three cores from each of three poles, were 9.8, 15.9, and 17.0 pounds per cubic foot (157, 254, and 272 kg/m^3).

Douglas-fir Poles

None of the ten 40- to 45-foot (122-13.7 m), creosote-treated, Douglas-fir poles inspected in December 1983 near Panama City had decay on the pole exterior. Two, however, were attacked by termites. information on brands indicated that poles were treated in 1968 to a retention of 10 pounds per cubic foot (160 kg/m^3). Penetration depths of creosote in those poles met specifications for Douglas-fir in all but one pole, which was sound.

Pole class	Depth of preservative penetration[4]		Termites present (+) or absent (–)
	in	*(mm)*	
4	1.8	(45)	—
4	1.5	(37)	—
4	1.7	(43)	—
4	1.3	(33)	—
2	1.1	(28)	—
3	0.5	(12)	—
2	1.3	(33)	+
3	1.3	(33)	—
3	1.3	(33)	—
3	1.6	(40)	—

[4]Information on brands indicates that poles were treated in 1968 to a retention of 10 pounds per cubic foot (160 kg/m^3).

The transmission line, inspected in 1984, comprised 54 poles. Of these, 48 were Douglas-fir that were originally installed in 1969. Two poles had definitely been replaced because of termite attack in the original poles. Two others were assumed to have replaced termite-attacked poles because they were located in a sequence of poles with termite attack. One pole was replaced because of a vehicular accident. One pole appeared to be added near an intersection after the original line had been established.

Termite attack appeared to occur in clusters of poles within the transmission line rather than randomly throughout the length of the line. Thirteen nonincised poles were distributed throughout the length of the transmission line. No distinct pattern of attack was recognized in the distribution lines, which generally circled residential areas. Differences in frequency of termite attack were noted between distribution lines (table 1), but for purposes of statistical comparison of termite attack in incised (24) versus nonincised (26) poles, all poles in distribution lines were grouped together.

Twenty-five percent of the remaining, original Douglas-fir poles (12/48) in the transmission line and 38 percent (19/59) of the Douglas-fir poles currently in the distribution lines were being attacked by termites (table 1). Where termite attack occurred, the heartwood of Douglas-fir poles could be destroyed (fig. 6). Eleven each of the termite-attacked transmission and distribution poles examined in this study were hollow. No significant difference in frequency of termite attack was detected between incised versus nonincised Douglas-fir poles.

Figure 6.—Termite destruction in the heartwood core of a creosote-treated Douglas-fir pole in Panama. (ML84 9076)

Table 1.—Condition of utility lines built in 1969 with creosote-treated Douglas-fir poles. Lines are located near Panama City and were inspected in 1984

Line	Pole		Total number poles in line	Number of original poles replaced due to bio-deterioration	Number of original poles remaining in service	
	Class	Length			Attacked by termites	Free from termite attack
		ft (m)				
Transmission	2-3	40-45 (12.2-13.7)	[1]54	[2]4	12	36
Distribution A	3	40-45 (12.2-13.7)	20	0	8	12
Distribution B	3-4	40-45 (12.2-13.7)	21	[3]1	6	14
Distribution C	3	40-50 (12.2-15.2)	5	0	2	3
Distribution D	3	40-55 (12.2-16.8)	[1]6	0	3	2

[1]Number of replaced and original poles in a line does not equal total number of poles in line because replacements for other than biodeterioration are not listed.
[2]Two were definitely due to termite attack of original pole. Two were probably due to termite attack.
[3]Confirmed by maintenance personnel.

Discussion

The variation in durabilities of creosote-treated southern pine poles seems attributable to two causes: (1) inadequate treatment of one lot of poles that were treated in 1974 and used near the Pacific end of the Panama Canal and (2) severe environmental stress for the line near Colon.

Admittedly, creosote analyses from just a few increment cores per pole do not give accurate retentions. Still, they provide a reasonable estimate. The marked contrast in assay results for the two lots of southern pine poles treated approximately 10 years ago suggest that differences in observed condition reflect original differences in treatments. Poles installed near the Pacific end of the Panama Canal apparently received inadequate amounts of preservative or were treated with a creosote mixture that was substantially below standard in composition. They now are succumbing to wood decay fungi and termites. Creosote retentions for those poles used as light standards presumably met specifications, and they are now sound. The difference in performance between these two lots of poles, located approximately 10 miles (16 km) apart in only slightly different environments, emphasizes the need for inspection of treated wood products for compliance with specifications at the time of purchase.

The difference in durability between the two lines of creosote-treated southern pine poles that were erected in different tropical environments in 1964-65 seems to reflect the impact of a more severe environment near Colon where the natural biome is a tropical rain forest. Whether this is caused solely by increased rainfall, a more uniform distribution of rain throughout the year, a different temperature, or an interaction of climatic and edaphic factors is not known. Boone (1965) observed differences in the durability of two lines of creosote-treated southern pine telephone poles in the high-rainfall areas on the island of Hawaii, but offered no explanation for those differences. Those differences were not obvious in the records until after 25 years of service. (Boone's report was based entirely upon data gathered from records. He did not conduct any personal pole inspections.) The composition of creosote is an important factor in protecting pine sapwood from decay in tropical environments (Tamblyn and Levy 1981), but the fact that poles in both lines were treated by the same firm at approximately the same time suggests comparable processing. Approximately equivalent retentions of creosote were found in poles at both locations. Groundline treatments might have been used on a few poles in the line near Panama City, but they certainly were not used extensively. I doubt that treatment of a few poles with groundline treatment would account for the major difference in durability that occurs between the Colon site, which has rainfall throughout the year, and the Panama City site, which has more distinct wet/dry seasons.

In Panama, termites pose a more serious hazard for creosote-treated Douglas-fir poles than do wood decay fungi. In Guam (DeGroot and Lauret 1986), such poles have been protected from Formosan termites by treating the soil around the poles with a termiticide. Given the frequency of termite attack in Douglas-fir poles observed in this study, it would seem prudent to use soil treatments with an approved termiticide in Panama, too. Incising poles during treatment does not appear to improve resistance to termite attack.

Groundline treatments with preservatives provide additional protection against decay for poles (Chudnoff et al. 1978). Application of groundline treatments of preservatives to poles before the onset of decay and at regular intervals thereafter should prolong the life of poles in service.

Conclusions

Current industrial and federal specifications (AWPA, U.S. Federal Supply Service) for creosote treatment of southern pine poles seem adequate for poles in most tropical environments. In regions of high, sustained annual rainfall, however, some variation in performance may occur. further studies are needed to determine the causes for deterioration at the groundline of creosote-treated southern pine poles in biome types that would naturally be classified as tropical rain forest.

Practical, supplemental steps can be taken to enhance the durability of creosote-treated southern pine poles in tropical rain forest regions. Application of prophyllactic treatments to tops of poles when they are installed could limit top decay. Similarly, application of groundline treatments to poles at intervals appropriate for the severity of the environment could limit decay at the groundline.

Observations of termite activity in Douglas-fir poles in Panama and in other tropical locations indicate that current specifications for creosote treatment of Douglas-fir poles do not provide protection for the heartwood against tropical species of termites. Supplemental soil treatments with an approved termiticide are needed in areas of termite infestation.

Literature Cited

American Wood-Preservers' Association. Standard C4. Poles--preservative treatment by pressure processes. In: AWPA book of standards. Stevensville, MD: American Wood-Preservers' Association; 1983. 6 p.

Boone, R. S. Service life of telephone poles on the island of Hawaii. Res. Note PSW-96. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station; 1965. 6 p.

Chudnoff, M.; Eslyn, W. E.; Wawriw, R. Effectiveness of groundline treatments of creosoted pine poles under tropical exposure. Forest Products Journal. 28(4): 28-32; 1978.

DeGroot, R. C.; Lauret, T. H. Durability of preservative--treated wood utility poles in Guam. Res. Pap. FPL 472. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory; 1986. 16 p.

Rural Electrification Administration. Pole inspection and maintenance. REA Bull. 161-4. Washington, DC: U.S. Department of Agriculture, Rural Electrification Administration; 1974. 50 p.

Tamblyn, N.; Levy, C. Field and marine tests in Papau New Guinea. III. Decay resistance of stakes treated with preservatives. Journal of the Institute of Wood Science. 9(2): 55-61; 1981.

U.S. Army Tropical Test Center. Material testing. in the Tropics. 6th ed. Miami, FL: U.S. Army Tropic Test Center; 1979.

U.S. Federal Supply Service. General Services Administration. Interim Federal Specification Wood Preservation: Treating practices. TT-W-00571 (AGR-AFS). Washington, DC: U.S. Forest Service, General Services Administration: 1974.

Whittaker, R. H. Communities and ecosystems. New York: MacMillan Publishing Co., Inc.; 1975. 385 p.

Pesticides used improperly can be injurious to human beings, animals, and plants. Follow the directions and heed all precautions on labels. Store pesticides in original containers under lock and key-out of the reach of children and animals-and away from food and feed.

Apply pesticides so that they do not endanger humans, livestock, crops, beneficial insects, fish, and wildlife. Do not apply pesticides where there is danger of drift when honey bees or other pollinating insects are visiting plants, or in ways that may contaminate water or leave illegal residues.

Avoid prolonged inhalation of pesticide sprays or dusts; wear protective clothing and equipment, if specified on the label.

If your hands become contaminated with a pesticide, do not eat or drink until you have washed. In case a pesticide is swallowed or gets in the eyes, follow the first aid treatment given on the label, and get prompt medical attention. If a pesticide is spilled on your skin or clothing, remove clothing immediately and wash skin thoroughly.

NOTE: Some States have restrictions on the use of certain pesticides. Check your State and local regulations. Also, because registrations of pesticides are under constant review by the U.S Environmental Protection Agency, consult your local forest pathologist, county agriculture. agent, or State extension specialist to be sure the intended use is still registered.

☆U.S. GOVERNMENT PRINTING OFFICE: 1986-641-044/40000

2.2-7/86