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wood pole maintenance manual:

inspection and supplemental treatment of douglas-fir and western redcedar poles

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FOREST RESEARCH LAB

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contents

summary

This Manual provides basic information that pole inspectors can use to make wise decisions that very largely will determine the success or failure of a wood pole program. Managers of wood pole systems can use this information to develop and to evaluate their maintenance programs.

Sections emphasize the characteristics of western redcedar and Douglas-fir, the wood-destroying organisms, and the tools and procedures for inspecting poles that provide the foundation for a maintenance program. Much has been written about external supplemental treatments, so discussion here is brief. However, because of a rapidly expanding use of fumigants throughout the United States and Canada, the Manual details recently developed fumigant treatments and their application to control internal decay.

Appendices cover supplemental references, a laboratory procedure for culturing fungi from wood, some sources of inspection equipment, and a computerized record-keeping system for pole maintenance.

For field use, a one-page summary of key items is available for maintenance vehicles as a reminder and checklist.

introduction

Safe, reliable, and economical transmission and distribution of electrical energy via wood poles require an efficient, effective program to detect and treat deteriorating poles before replacement becomes necessary. This means inspection within 5 to 20 years after installation. Timing of the first inspection will vary with the species of wood used for the pole, its age and location, and many other variables that influence the service life of poles.

Badly deteriorated poles are easy to detect, but poles in earlier stages pose a more difficult, yet challenging problem. The success or failure of the maintenance program rests squarely on the ability of you, the pole inspector, to correctly assess the condition of poles. This is no easy task.

This manual will help you learn how to make those decisions. You will learn:

- wood properties of Douglas-fir and western redcedar.
- wood-destroying organisms and evidence of their damage.
- inspection techniques to determine a pole's condition.
- treatments for poles in service.

After studying this material, we urge you to read other references, both those cited in the text and listed in Appendix A, so you can select and test different ideas and procedures that will meet the needs of your wood pole system.

Before inspecting poles in line, you first should inspect poles that have been removed from service. Cut them into short sections from butt to tip. Split the sections to reveal patterns of preservative penetration and patterns of deterioration and its origin. Cut up both "bad" and "good" poles because that is the best way to learn how to inspect poles in service. The loss of a few "good" poles is a small price to pay for the experience you will be able to apply in decisions about thousands of poles. Informed decisions save lives and badly needed funds; incorrect decisions endanger lives and waste money.

Finally, as a reminder of safe practices you should follow when inspecting and treating poles, we've included a checklist (p. 59) that can be reproduced and placed in maintenance vehicles.

When you've finished reading the manual, test your knowledge of pole maintenance with the keywords inside the back cover.

wood

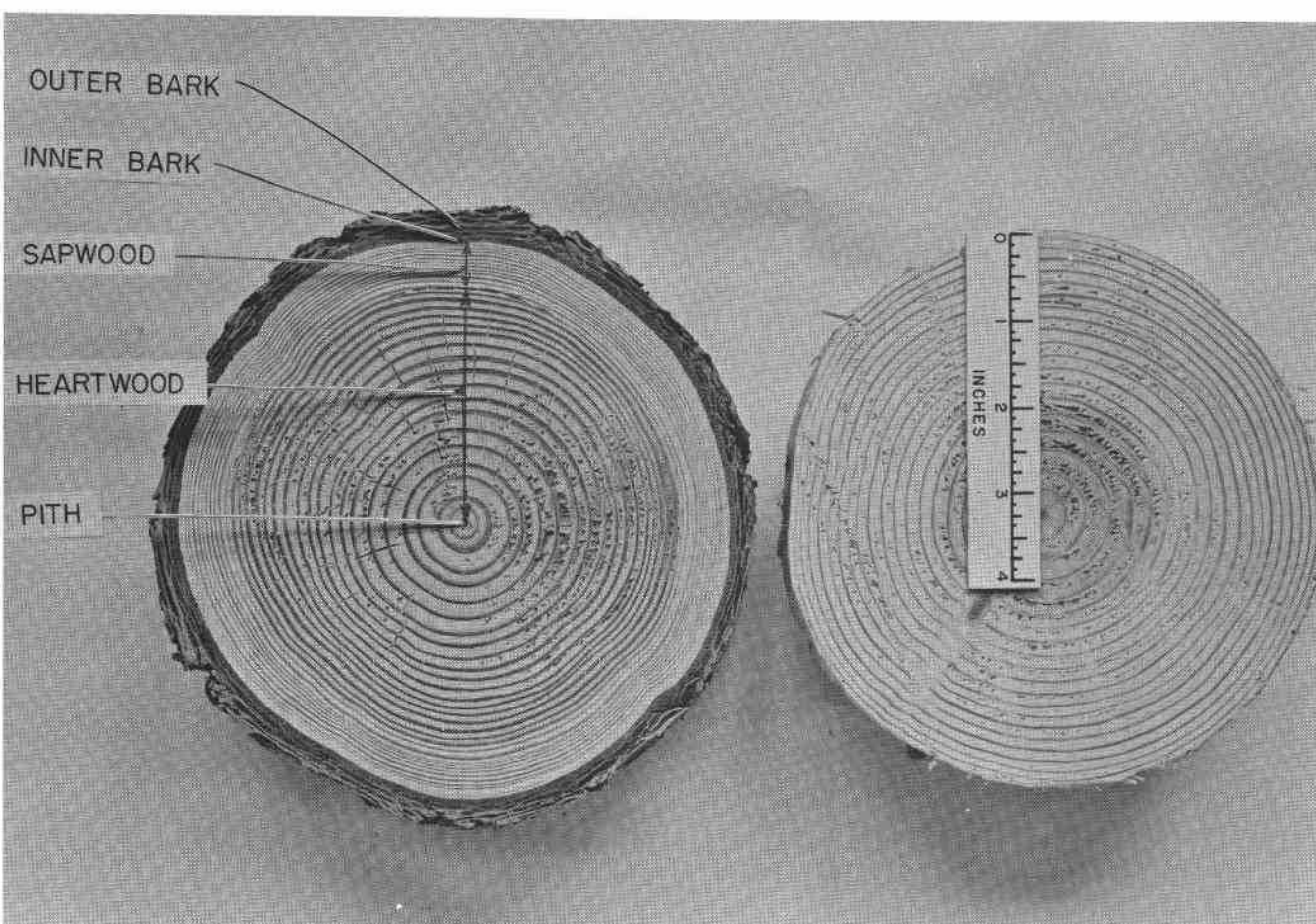
Cross-cut a Douglas-fir or cedar tree, and inside the bark you will find a zone of white sapwood surrounding a core of dark colored heartwood (Fig. 1).

Sapwood depth varies both with species and within a species. Sapwood of western redcedar usually is less than 1 inch thick, whereas sapwood in Douglas-fir increases with diameter (Fig. 2) from about 1 inch in small poles to about 2 inches in very large poles (Lassen and Okkonen 1969). Fast growing, vigorous trees usually have deeper sapwood than slow growing trees reflecting differences in size of tree crowns. Chemicals can be used to help distinguish between sapwood and heartwood (Barton 1973, AWPA).

Ninety percent of wood is made up of minute, hollow fibers oriented lengthwise along the tree stem (Fig. 3). These fibers, 1/5-inch long, are 100 times longer than wide. Through them, the tree transports water and nutrients from the roots up the sapwood to the leaves. The remaining 10 percent of the wood is composed of short, hollow, brick-shaped cells oriented from the bark towards the center of the tree as ribbons of rays of unequal height and length. These rays distribute food, manufactured in the leaves and transported down the inner bark, to the growing tissues between the bark and wood.

Figure 1.

Cross-sections of Douglas-fir show typical sapwood (left) and deep sapwood (right).



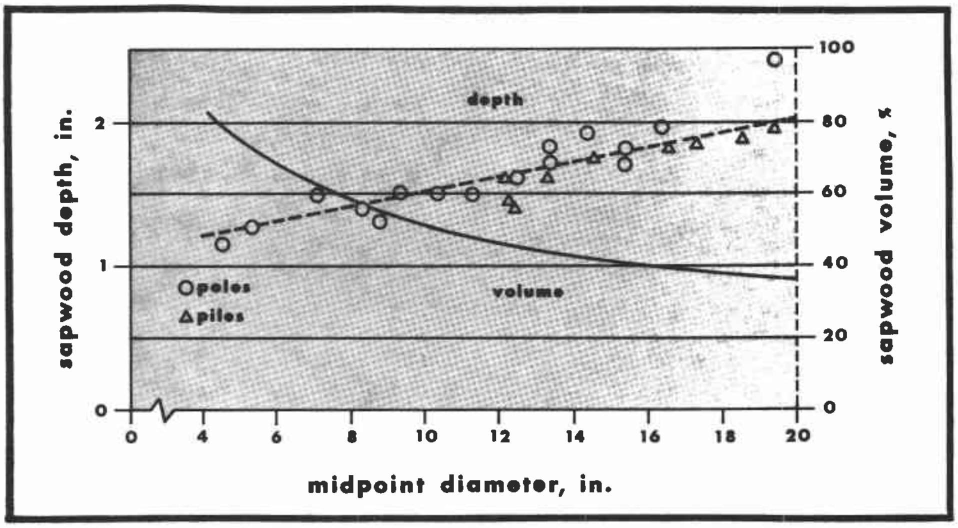


Figure 2.

Depth and volume of sapwood vary with the diameter of poles and piles of Pacific Coast Douglas-fir.

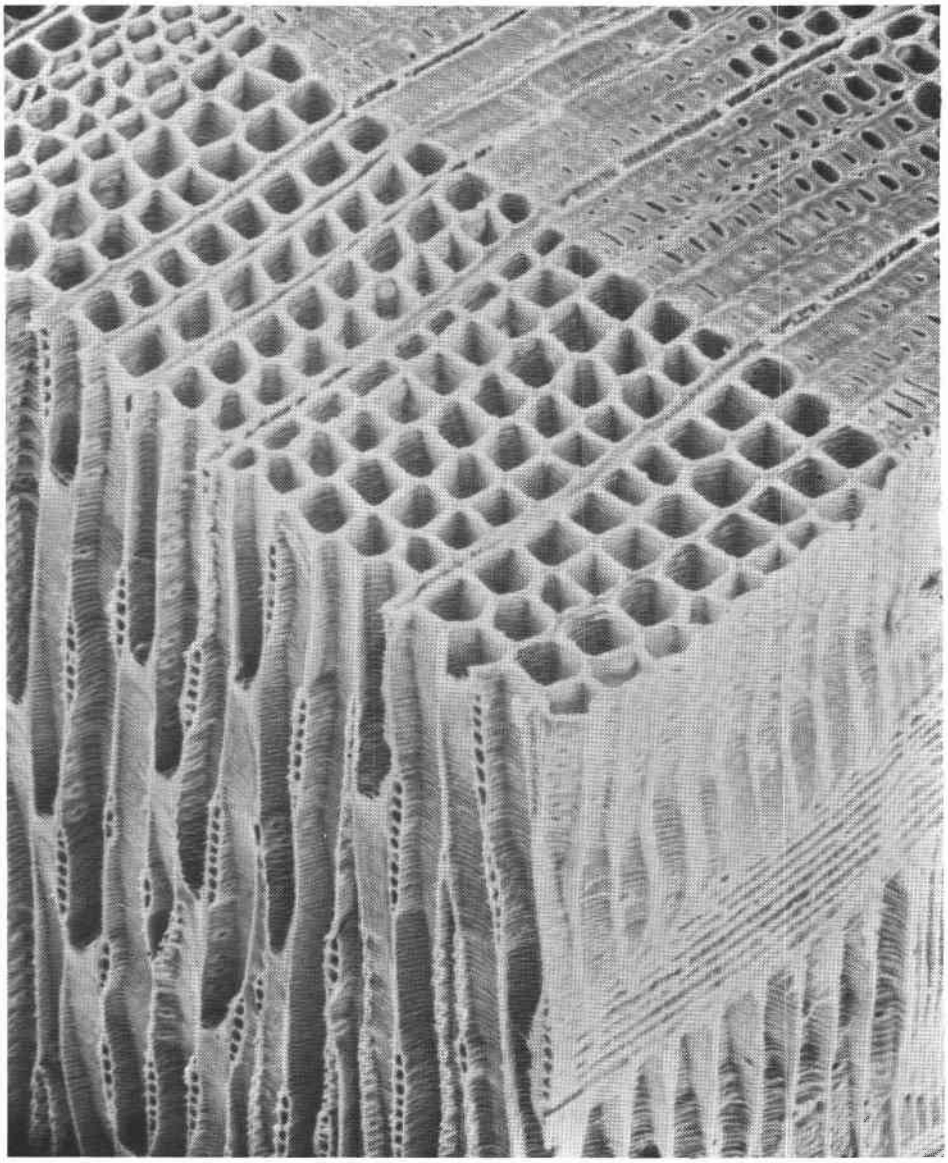


Figure 3.

In this greatly enlarged view of fibers in Douglas-fir, large open ends of thin-walled springwood fibers change abruptly to thick-walled summerwood fibers. Horizontal ribbons of short ray fibers are interspersed among long vertical fibers that make up about 90 percent of the wood. Photo provided by courtesy of the N.C. Brown Center for Ultrastructure Studies, College of Environmental Science and Forestry, State University of New York, Syracuse.

durability

Unprotected sapwood of all trees deteriorates rapidly in warm, moist soil. Douglas-fir, western larch, western hemlock, and most other species also have nondurable heartwood. In Oregon, posts of nondurable woods have an average service life of about 5 years compared to 30 years or longer for posts pressure-treated with preservatives (Miller and Graham 1977). Heartwood of cedar, redwood, and a few other species is durable, lasting three to five times longer than nondurable woods. Preservative treatments increase the service life of cedar poles from about 15 to more than 30 years. However, the scarcity of pole-size cedar trees means that the more abundant species with nondurable heartwood will increasingly be used as poles.

density

Because of its low density, wood of cedar is lightweight when dry but may be very heavy when wet. Low density wood contains more voids than high density wood and, therefore, more space for water. One cubic foot of water-free (ovendry) western redcedar weighs about 19 pounds, about 9 pounds less than Douglas-fir, which is denser.

Because density reflects the thickness of the fiber walls, it indicates the strength of the wood. The higher the density of wood at a specified moisture content (MC), the greater its strength. To support the same load, a cedar pole must be larger in diameter than a Douglas-fir pole. Nature designed trees well because wood density is highest near the ground where strength is needed and lowest near the top.

moisture content

Sapwood, which conducts nutrients in water from the roots to the leaves, is nearly saturated with water. The lower density at the top enables a tree to store large quantities of water where it will be readily available to the leaves. Heartwood usually contains much less water.

Because of its low density, cedar can hold much more water than Douglas-fir. In freshly cut cedar trees, sapwood and heartwod have moisture contents near 250 percent and 60 percent, calculated on a water-free wood basis.

Moisture content is expressed as a percentage of the dry weight of the wood. To determine the amount of water in wood, weigh pieces of the wood, then dry them in an oven at 220°F until their weights remain constant—wood 1 inch thick or less usually dries within 24 hours. Do not use wood that contains pitch because it evaporates with the water.

Then the moisture content can be calculated as:

MC = (initial weight/ovendry weight) - 1 x 100

or

MC = [(initial weight - ovendry weight)/ovendry weight] x 100

For example, if 1 ft^3 of Douglas-fir sapwood weighs 60.2 pounds and its ovendry weight is 28.0 pounds, the calculations would be:

MC = (initial weight/ovendry weight) - 1 x 100
MC = (60.2/28.0) - 1 x 100
MC = 115% MC

or

MC = [(initial weight - ovendry weight] x 100
MC = [(60.2 - 28.0)/28.0] x 100
MC = 115% MC.

This calculation and three other examples are detailed in Table 1.

Table 1.

EXAMPLES OF HOW TO CALCULATE MOISTURE CONTENT OF ONE CUBIC FOOT OF WOOD.

	Douglas-fir		Western redcedar	
Function	Sapwood	Heartwood	Sapwood	Heartwood
Initial weight (pounds) minus	60.2	38.4	66.5	30.4
Ovendry weight (pounds) equals	28.0	28.0	19.0	19.0
Weight of water (pounds) divided by	32.2	10.4	47.5	11.4
Ovendry weight (pounds) equals	28.0	28.0	19.0	19.0
Moisture content times 100 equals	1.15	0.37	2.50	0.60
Moisture content (percent)	115%	37%	250%	60%

Moisture content also can be determined with a moisture meter that measures the electrical resistance between two probes driven into the wood with a sliding hammer (James 1975, Salamon 1971). Because a moisture gradient indicates moisture distribution in a pole much better than a single reading at a specified depth, the 3-inch long probes with uncoated tips should be driven into the wood so that the meter is read every 1/2 inch. Before driving the probes into the wood, be sure that they parallel each other and align with the long fibers of the wood—that way the probes will not break off, and the data will be more accurate. The meter is useful for moisture contents ranging from 7 to 25 percent, but accuracy decreases rapidly above that; meter readings were low for Douglas-fir with moisture contents exceeding 20 percent (Graham et al. 1969). Creosote and oil-borne preservatives have little effect on meter readings, but inorganic waterborne preservatives may cause large errors (James 1976).

shrinkage and checking

As poles dry or season, they lose water from the surface, but the poles shrink only when the moisture content drops below 30 percent. Then—because wood shrinks more along than across the growth rings—numerous, small, V-shaped checks form in the surface of poles. As drying continues deeper into the wood, the number of small checks decreases, but a few checks drive deep into the wood (Fig. 4). Deep checks to the center indicate a well-seasoned pole. Numerous small checks do not always reliably indicate the extent of seasoning because some poles check very little as they dry. However, most poles eventually develop narrow or wide deep checks.

Even under the most favorable conditions, large poles require an excessively long time to kiln dry (Graham and Womack 1972) or air dry (more than 2 years). Consequently, some poles are treated with preservatives and put in service while they still have high internal moisture contents. As checks on these poles continue to deepen, they expose untreated wood to attack by wood-destroying organisms, so the poles decay internally.

Poles susceptible to this internal decay cannot be reliably detected by visually examining checks for untreated wood. When we cross-cut poles, we found that such visual inspection seriously underestimated the number of poles with checks that extended beyond the treated wood; even narrow checks exposed untreated wood. Nor was probing with a narrow blade a reliable measure of check depth.

Figure 4.

Narrow checks that widened and deepened after treatment expose the untreated heartwood of this Douglas-fir pole to rot by decay fungi.

pole specifications

Because sapwood must be dried to a moisture content of 30 percent or less to meet preservative penetration-retention requirements for poles, some utilities have specified moisture contents of 20, 25, or 30 percent at depths of 1, 1 1/2, or 2 1/2 inches from the surface before treating. Such moisture contents do not necessarily control checking. When placed in service, the interior of these poles will continue to dry, and some checks will continue to deepen. In western Oregon which has a relatively mild, moist climate, poles in service attain summer moisture contents of 10 to 15 percent just above ground and 25 to 40 percent below ground (Fig. 5). The low moisture contents just above the groundline are critical because they are much less than those to which large

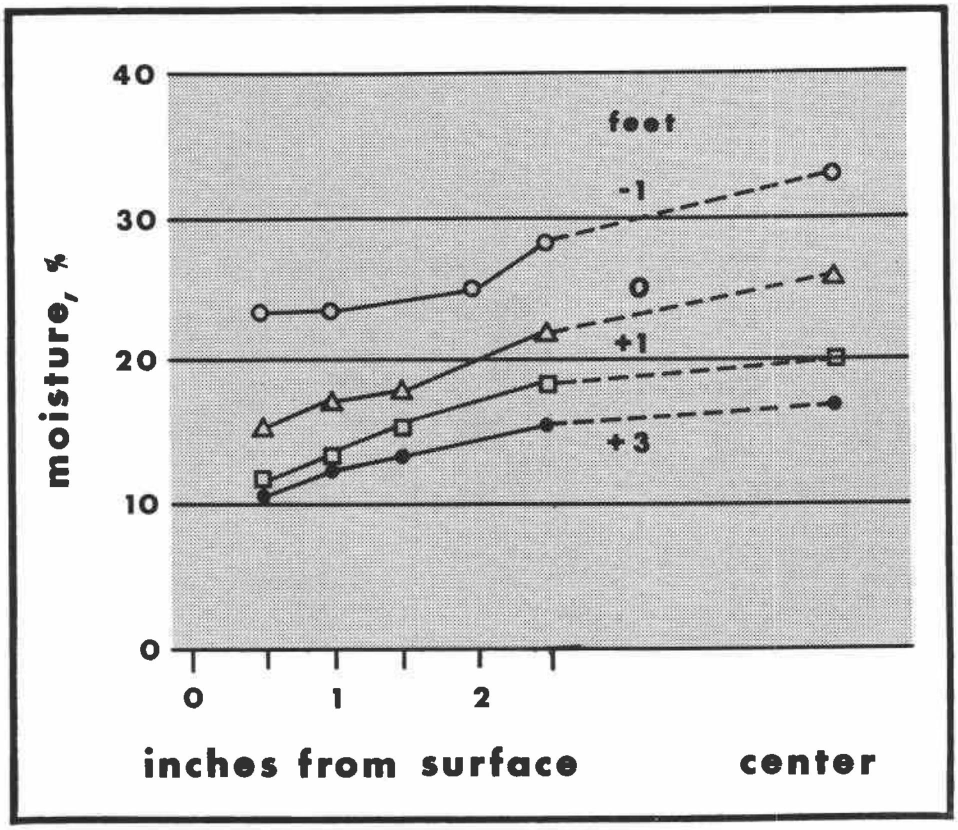


Figure 5.

Moisture content increased towards the center and from above ground to below ground in 10 pressure-treated Douglas-fir transmission poles that were in service near Corvallis, Oregon, for 13 years.

poles can be economically dried before being placed in service.

Neither moisture content specifications nor seasoning can be depended upon to control checking of large poles in service. To solve this problem, a steadily increasing number of electric utilities are deeply incising or perforating poles before treatment to obtain deep preservative penetration. Others are kerfing poles to the center from the butt end to 5 or more feet above the groundline zone to prevent checking.

preservative treatment

Untreated poles usually are purchased according to specifications of the American National Standards Institute (ANSI 1972). Subsequently, most poles are treated with preservatives as specified by the American Wood-Preservers' Association (AWPA). Pole standards specify a minimum depth of preservative penetration and the retention of a minimum quantity of preservative in a specified assay zone of wood (AWPA) although a utility company may modify those standards to meet its special requirements.

Preservatives can easily penetrate dry sapwood to provide a well-protected sapwood shell with the preservative concentrating near the surface where it is needed most. The increasing moisture content with depth of sapwood also favors such a concentration gradient. To improve uniformity of treatment, untreated poles may be pierced with numerous slits or holes to various depths.

Because heartwood is more difficult to penetrate with preservatives, the groundline zone of Pacific Coast Douglas-fir poles may be punctured with numerous slits 2 1/2 inches deep (Best and Martin 1969) or perforated with rows of parallel holes (Graham et al. 1969) that expose the ends of the long wood fibers. These openings permit preservative to flow along the grain of the heartwood. However, they do little to improve treatment of the very difficult-to-treat heartwood of interior Douglas-fir from east of the Cascade Mountains (Miller and Graham 1963) and western redcedar.

Another successful approach to overcome the problem of checking beyond the treated shell in Douglas-fir and cedar poles is to saw a kerf to the center from the butt to 5 or more feet above the groundline before preservative treatment (Graham 1973, Helsing and Graham 1976).

Douglas-fir poles are treated full-length by pressure processes. Western redcedar poles may be similarly treated, but most are butt- or full-length treated by a thermal process. Preservatives used to treat poles include creosote, pentachlorophenol dissolved in various solvents (heavy petroleum, light petroleum, or liquefied petroleum gas), and formulations of copper and arsenic in water. The waterborne preservatives react to form new chemicals that resist leaching. All preservatives approved for ground contact ensure long service life.

wood-inhabiting fungi

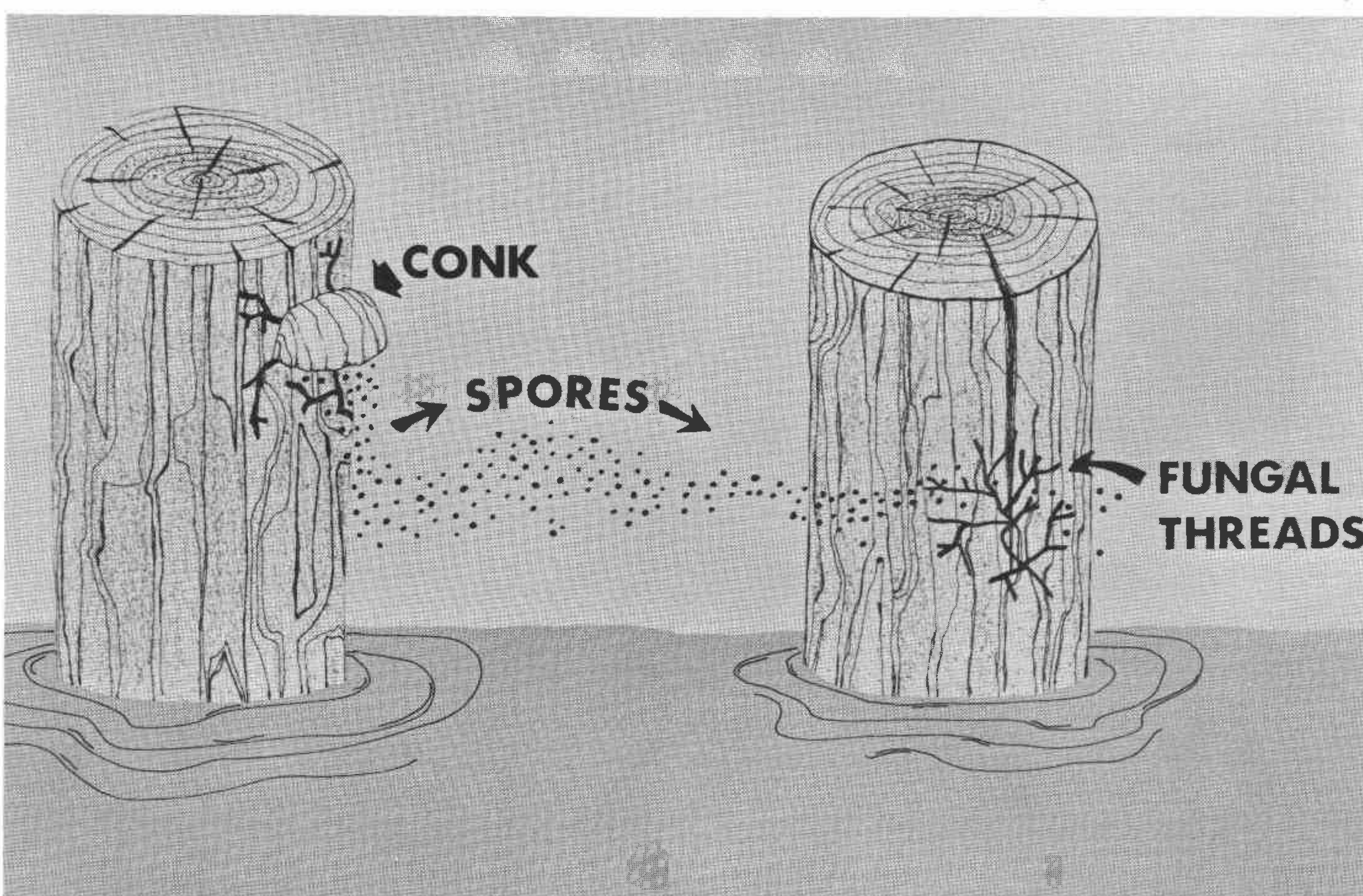
The structural integrity of wood may be destroyed by decay fungi, plants that feed on wood. Fungi require water, air, a favorable temperature, and food. Wood with a moisture content below 20 percent (ovendry basis) usually is safe from fungi. Air limits fungal growth only when wood is submerged in water or buried deep in the ground. Freezing temperatures stop fungal growth but seldom kill fungi. Above 32° F, fungal activity increases, peaking between 60 and 80° F and decreasing as temperatures approach 100° F. Most fungi are killed at temperatures exceeding 150° F.

Wood also contains a wide variety of "nondecay" fungi that usually do not weaken wood. The interaction of fungi, both decay and nondecay types, and their roles in the decay process are still to be defined.

decay fungi

Mushrooms and "conks" are typical fruit bodies of **decay fungi** that produce billions of microscopic seed-like structures called spores (Fig. 6). Finding favorable conditions, these spores germinate and produce hyphae, minute thread-like strands that penetrate throughout the wood. The hyphae secrete enzymes that dissolve the cellulose and lignin of wood into simpler chemicals that fungi can use as food.

"Decay" describes wood in all stages of fungal attack, from the initial penetration of hyphae into the cell wall to the complete destruction of the wood. Early fungal attack on wood usually can be detected only by microscopic examination or, as explained in Appendix B, by incubating wood on nutrient agar



for outgrowth of decay fungi (Fig. 7). If decay fungi can be cultured from wood that appears sound (free of decay), the solid wood is in the incipient stage of decay. During the early stages of decay, some fungi may discolor the wood or substantially weaken the wood, especially its toughness.

As decay continues, wood becomes brash (breaks abruptly across the grain), loses luster and strength, and noticeably changes in color; eventually, it may be completely destroyed. Wood that is visibly decayed, greatly weakened, and conspicuously brash or soft, is in the advanced stage of decay called rot. Brown rot—a brown, advanced decay that crumbles when dry—is common in most softwoods. Although it is called "dry rot," this nomenclature is misleading because at one time the wood must have been wet enough to support fungal growth. White-rot fungi bleach or whiten wood in the advanced stage of decay, or they form small white pockets in rotten brown wood. Soft-rot fungi that slowly cause an external softening of treated wood have extensively damaged poles below ground.

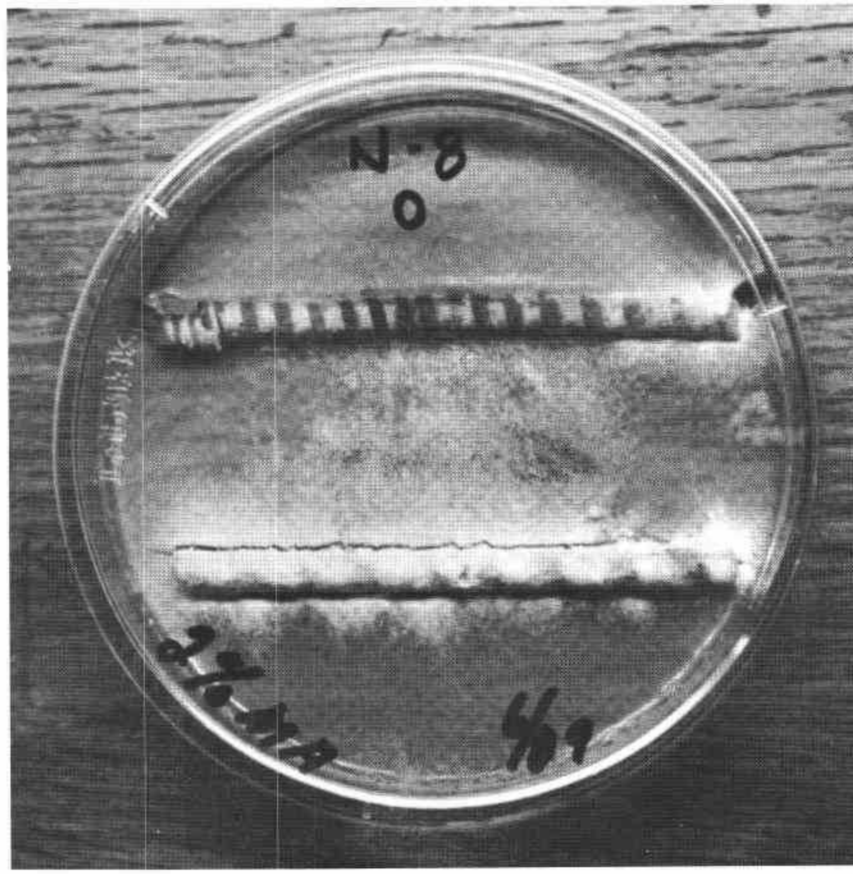


Figure 7.

A decay fungus growing over malt agar from a sound-appearing increment core is a positive sign of decay, even though the pole may contain no rot.

nondecay fungi

Numerous so-called nondecay fungi also inhabit wood, feeding on cell contents, certain components of cell walls, and the products of decay. Frequently only nondecay fungi can be isolated from rotten wood. Sapwood-staining fungi may reduce the toughness of severely discolored wood; other nondecay fungi gradually detoxify preservatives, preparing the way for decay fungi. Rapidly growing nondecay fungi frequently interfere with the culturing of the slower growing decay fungi.

Figure 6.

The conk (fruit body) of a decay fungus produces microscopic spores that, finding suitable conditions for growth, infect other wood products. Fungal threads spread decay through moist wood.

decay patterns

Untreated poles first rot in the sapwood just below the groundline where moisture and air are most favorable for fungal growth. Once established, this external rot may extend several inches or more into the heartwood, especially around seasoning checks. In dry soils, the rot may extend 2 feet or more below the ground. Although aboveground wood may contain less than 20 percent moisture, the poles may decay as rain water collects in seasoning checks, in end-grain at the top, and in holes drilled for attachments. In moist climates, poles with untreated sapwood above ground may have either surface rot or shell rot below the surface. By leaving an outer shell of solid wood, the hidden shell rot makes climbing hazardous for linemen. Untreated poles or piles in fresh water deteriorate above the water line but not below where the oxygen supply is limited.

Decay patterns vary greatly for treated poles of Douglas-fir with its low-durability heartwood and of cedar with its durable heartwood (Graham and Mothershead 1967).

In western redcedar, external rot usually can be cut off to expose bright, sound heartwood. Shell rot occurs frequently above ground in moist climates, making a hazard for linemen in about 12 to 15 years. Loss of the thin sapwood usually does not seriously reduce the strength of cedar poles. Internal rot usually is found at or below the groundline and sometimes at the very top of poles. Pockets of internal rot nearly always are clearly defined with a sharp demarcation between rot and sound, bright wood (Fig. 8). Depending on the depth of the water table, cedar poles in dry soils can rot both externally and internally several feet below ground.

Pressure-treated poles of Douglas-fir very rarely have external rot above ground and only infrequently below the groundline. However, the groundline zone should be checked periodically, especially on poles treated with new preservatives or processes. In pressure-treated poles of Douglas-fir, internal rot nearly always is associated with (1) checks that terminate near or below the groundline, or (2) above ground with checks, bolt holes, woodpecker holes, and cuts made during installation. When tops of pressure-treated poles are cut off, failure to protect the newly exposed, untreated wood leads to rapid decay. Internal rot can vary from small pockets (Fig. 9) to complete loss of the central core. If a pocket of rot is detected, decay fungi sometimes can be cultured from much of the surrounding cross-section for several feet above and below the pocket. Usually no clear line separates sound (undecayed) and rotten wood in Douglas-fir.

Figure 8.

Rot pockets in cedar poles are well-defined with an abrupt transition to "sound" wood. Each pocket is connected with a seasoning check. The central pocket extends about 3 feet below the groundline.

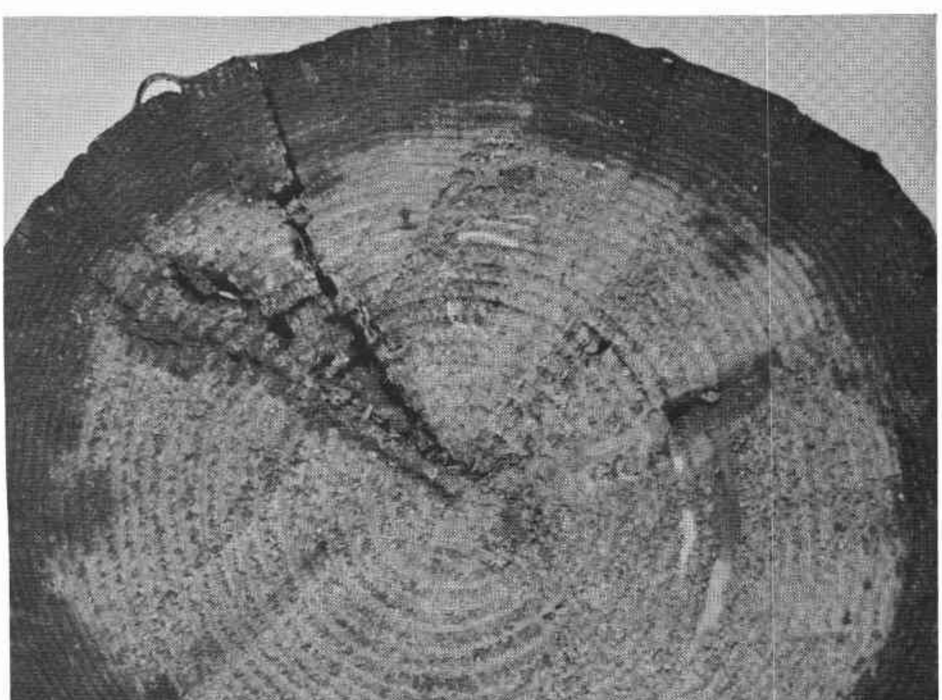


Figure 9.

The small rot pocket in this Douglas-fir pole section is associated with a narrow, but deep, seasoning check. The small white areas are tunnels of Buprestid beetles. Most of the solid untreated wood probably is infested with the decay fungus.

other wood-inhabiting organisms

Insects, woodpeckers, and marine boring animals also can extensively damage wood structures in some areas, although decay fungi are by far the most destructive organisms.

insects

Wood in or above ground may be attacked by termites, carpenter ants, or beetles. Termites work within wood with virtually no external evidence of their presence until winged adults emerge and swarm in late summer and early fall. Then their wings, discarded for mating and starting new colonies, may indicate their presence. Although their lengths vary from 1/4 inch or less (subterranean and drywood) to 3/4 inch (dampwood), termites have bodies of fairly uniform width; the reproductives have wings of equal length (Fig. 10).

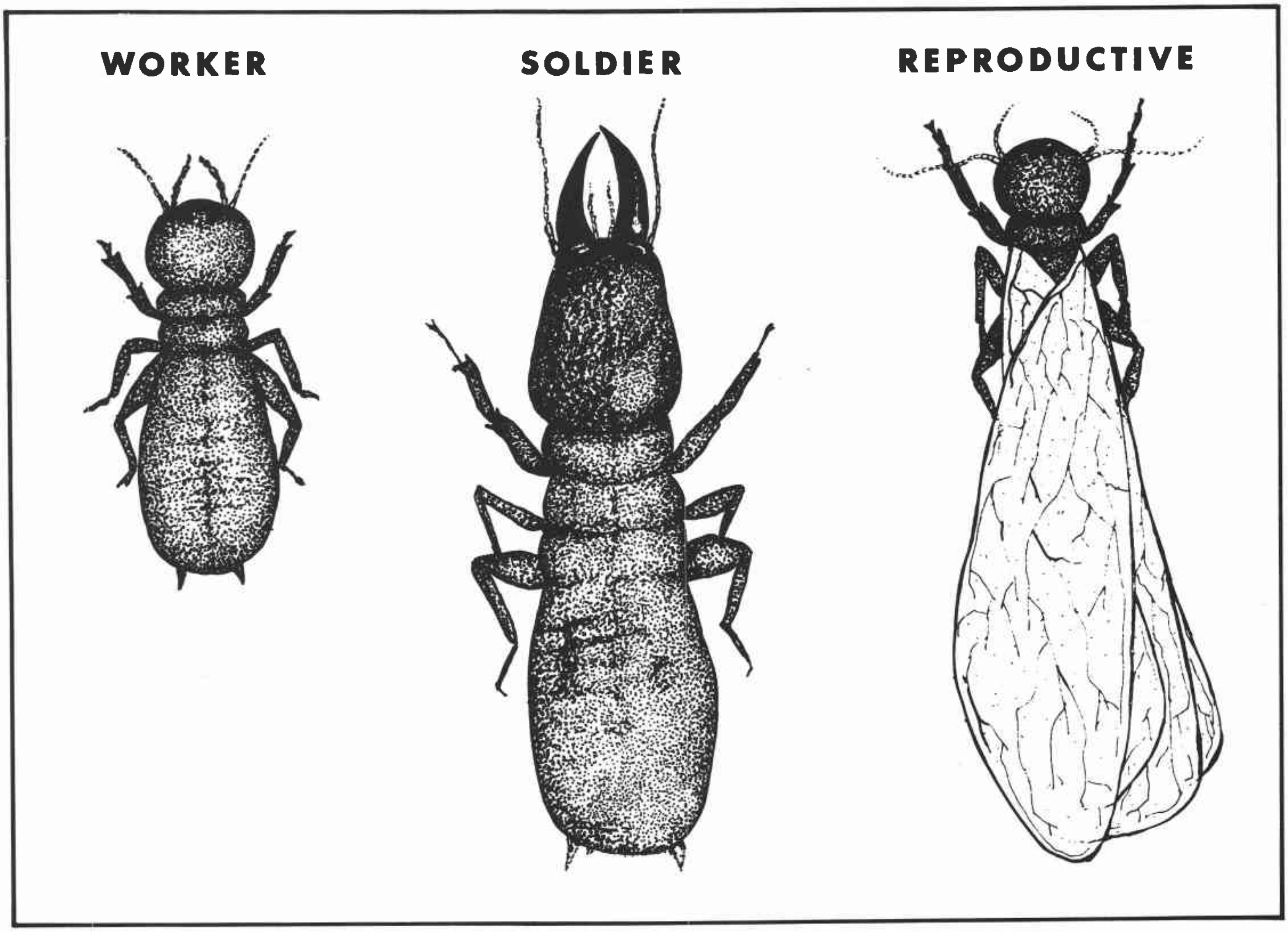
Subterranean termites are widespread and cause extensive damage, especially in southern states. Sure signs of their presence are the mud tunnels that only subterranean termites build from the ground where they nest across treated wood or concrete to reach untreated wood above. Dampwood termites inhabit moist wood in, on, or above the ground along the Pacific Coast. Drywood termites feed on dry wood, primarily in the southern United States.

Carpenter ants have a restricted waist, and the reproductives have wings of unequal length (Fig. 11). The dark-color ants grow as long as 3/4 inch. Unlike termites that eat wood, ants hollow out wood only for shelter, forming piles of "sawdust" at the base of poles that attest to their presence. Ants frequently may be seen scurrying around poles in search of food.

Although many different beetles attack wood products, the Buprestid is the most common in the Pacific Northwest. This metallic golden or green beetle, 3/4 inch long, makes an elliptical hole as the adult emerges from the pole to mate (Fig. 12). Trained pole maintenance personnel recognize these elliptical holes as an indicator of internal rot often associated with attacks by the Buprestid beetle. Numerous emergence holes may indicate an unsafe pole.

woodpeckers

Woodpeckers sometimes nest in poles, drum on poles as part of their mating ritual, use poles as a source of insects, store acorns in small holes as a future food source, and make holes for other unknown reasons. Chemical repellents, plastic wraps that deny the birds a toe hold, stuffed owls, and pole sections attached to poles all have been used with varying, but usually little, success to prevent woodpecker damage. Heavy galvanized hardware cloth applied tightly over much of the pole has been most successful. Because the holes permit water to enter poles, fungal decay compounds the woodpecker problem.



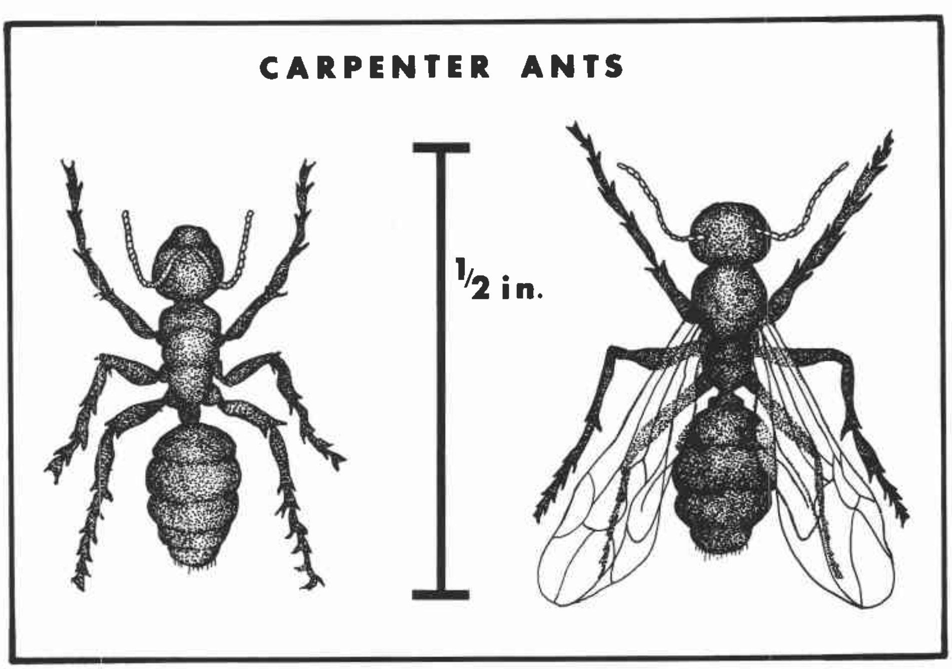


Figure 10.

A termite colony includes numerous workers that burrow in wood for food and shelter, fewer soldiers that protect the colony from other insects, and a single egg-laying queen. Usually poles show no sign of termites until the reproductives emerge, discard their wings, and mate to start new colonies.

Figure 11.

Carpenter ants also live in colonies, hollowing out nests in poles for shelter. A pile of sawdust at a pole's base is a sure sign of their presence. In contrast to termites, ants have restricted waists and shorter wings of unequal length.

marine borers

Untreated wood piles and poles in coastal waters are attacked rapidly by marine borers. Shipworms riddle interior wood with long holes, and Limnoria (gribbles) burrow small tunnels near the wood surface (Fig. 13).

Shipworms are bivalves (mollusks) with a pair of small shells at their heads. As small larvae, they burrow into wood and continue to tunnel away from the hole. Their tunnels may be up to 3/4 inch in diameter and 2 feet long.

Gribbles, small crustaceans about 1/10 inch long, tunnel in large numbers just below the surface of wood. Because waves break off the weakened surface layers of wood, gribbles gradually reduce the effective diameter of the wood.

Marine borers are very destructive in southern latitudes where wood needs special preservative treatments. In northern latitudes, they do little damage to wood pressure-treated with marine-grade creosote or wood with high retentions of certain water-borne salts unless cracks, bolt holes, or cuts expose untreated wood. Pentachlorophenol-treated wood should not be used in marine waters. Untreated wood should not be fastened to treated wood because borers can become established in the untreated wood and penetrate the treated wood.

Figure 12.

As an indication of internal rot in the aboveground portion of poles, look for oval-shaped holes 1/2 inch long that the Buprestid beetle leaves as it emerges from wood. Many holes could mean an unsafe pole.

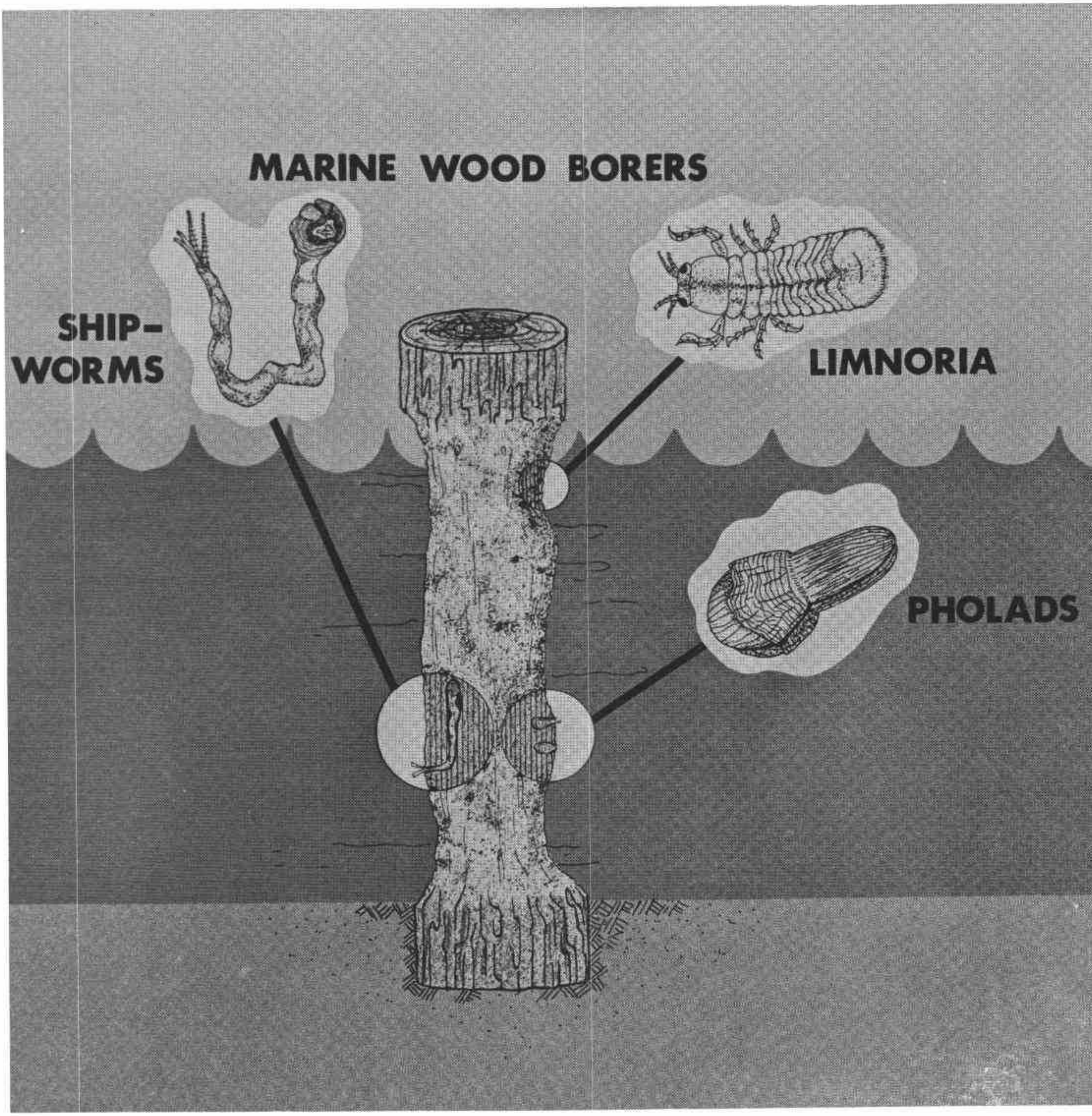


Figure 13.

Marine borers attack wood in coastal waters where salinity and oxygen supply are favorable.

detecting decay

In western Oregon, incipient decay can develop in untreated pole tops within 1 year and reach the visible advanced stage called rot within 2 to 4 years. Incipient decay also can extend 4 feet or more above internal rotten areas in the groundline zone of Douglas-fir poles. Because incipient decay is invisible to the unaided eye, it cannot be reliably detected in the field. Research on chemicals that color decaying wood or change electrical and chemical properties of wood eventually may lead to field detection methods. Meanwhile, microscopic examination or culturing of wood are the only ways to detect decay fungi in solid wood.

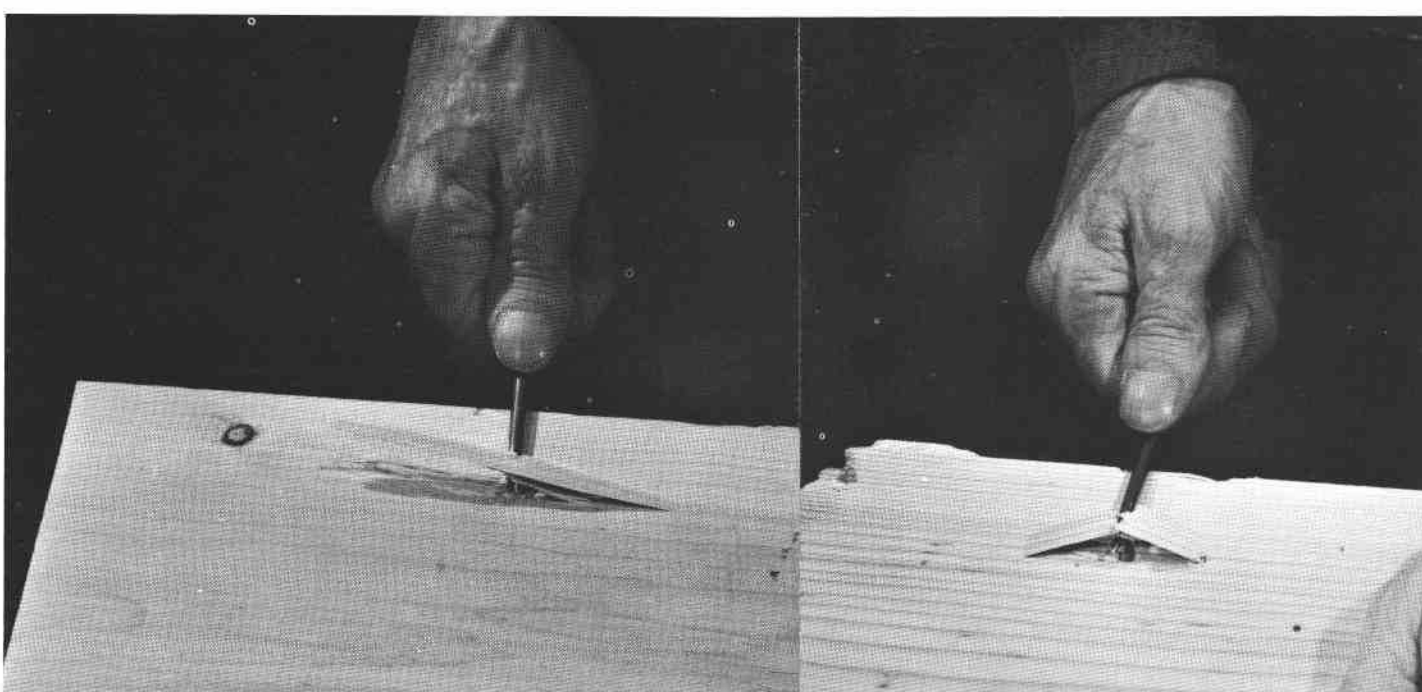
Culturing cores from poles (Appendix B) takes about 4 weeks for fungi to grow, then trained personnel (for example, plant pathologists) must use microscopes to distinguish between decay and nondecay fungi. Nevertheless, numerous cores can be cultured simultaneously.

Eventually, decaying wood becomes discolored or the physical properties of its fibrous structure change sufficiently to be recognized as rot. Sound wood has a fibrous structure and splinters when broken across the grain, whereas rotten wood is brash and breaks abruptly across the grain or crumbles into small particles. Decaying wood also may have an abnormal moldy or pungent odor. Wet sound wood, much softer than dry sound wood, frequently is confused with rot on the surface of poles below groundline. If in doubt, use the "pick test" (Fig. 14). Lift a small sliver of wood with a pick or pocket knife and notice whether it splinters (sound) or breaks abruptly (rotten). Sound wood has a solid feel when scraped or probed. Surface rot feels soft and usually has minute fractures like charred wood. Remember—"sound" and "solid" wood cannot be reliably distinguished in the field!

As discussed earlier, rot in cedar heartwood may occur as voids or as well-defined pockets of rotten wood abruptly changing to the adjacent sound heartwood. In Douglas-fir, the change from rotten to sound wood is much less distinct because incipient decay

Figure 14.

Use the "pick test" to detect rot. When a sliver of wood is lifted, abrupt failure usually indicates rot (right), whereas a splintering failure indicates solid wood (left). Photo provided by courtesy of the U.S. Forest Products Laboratory, Madison, Wis.



usually extends a considerable distance from the rot.

Drilling may reveal natural voids that can be confused with decay, or wet wood may drill easily like decayed wood. Ring shake, a natural separation along a growth ring, usually creates a short radial void with wood on both sides that feels solid. Internal radial checks create long narrow voids that may or may not be coated with preservative. In cedar poles, hollow centers caused by decay fungi in living trees can be misleading. Fortunately, few fungi that decay living trees continue to decay wood in service.

Surface rot can be detected by scraping, probing with a dull tool, and visually examining the wood. Internal decay is detected by sounding, drilling, coring, measuring electrical resistance, or feeling a metal probe as it is pulled across the growth rings. Poles with extensive rot are easy to detect, but detection becomes more difficult as the extent of the rot decreases. The sooner decay can be detected, the earlier preservative treatments can be applied to retain the structural integrity of poles. Select the equipment that best meets your needs. Some sources of equipment are listed in Appendix C.

Practice scraping, probing, lifting slivers, drilling, and coring both sound and decaying poles to improve your ability to detect rot.

scraping devices

A shovel, scraper with triangular blade, or dull probe can be used to detect belowground rot on the pole surface. Cutting the blade of a shovel back several inches facilitates removal of earth around poles and from the surface of poles. If scraping exposes untreated wood, treat that area with a preservative solution or paste.

hammer

In the hands of an experienced inspector, a hammer is a simple, rapid, and effective tool for sounding poles to detect internal rot. Use a lightweight hammer that is comfortable to swing and strong enough to stand repeated solid blows to the pole. Start hammering as high as you can reach, and work down the pole. Experienced inspectors can tell much about a pole by the "feel" of the hammer during sounding. A sharp ring indicates sound wood, whereas a hollow sound or dull thud indicates rot. Because seasoning checks, internal checks, and knots can affect the sound, suspicious areas should be drilled or cored with an increment borer. A leather punch 1/4 inch in diameter can be welded to the back of the hammer to make a starter hole for an increment borer bit.

increment borer (bit, handle, and extractor)

Originally used to measure tree growth, an increment borer has a hollow, fine-steel bit to extract wood cores. These are examined for rot and measured for shell thickness and depth of preservative treatment (Fig. 15).

To speed coring and reduce breakage of the expensive bits, make starter holes 1/2 inch deep and 3/8 inch in diameter with a punch mounted on a hammer or with a battery-powered drill. If boring resistance increases, back out and remove the core before boring deeper. Unusual or abrupt force can snap the bit or pack wood in so tightly that the bit must be drilled out. Rubbing bits with a moistened bar of soap eases drilling.

To speed drilling, mount the bit in the end of an extension (open

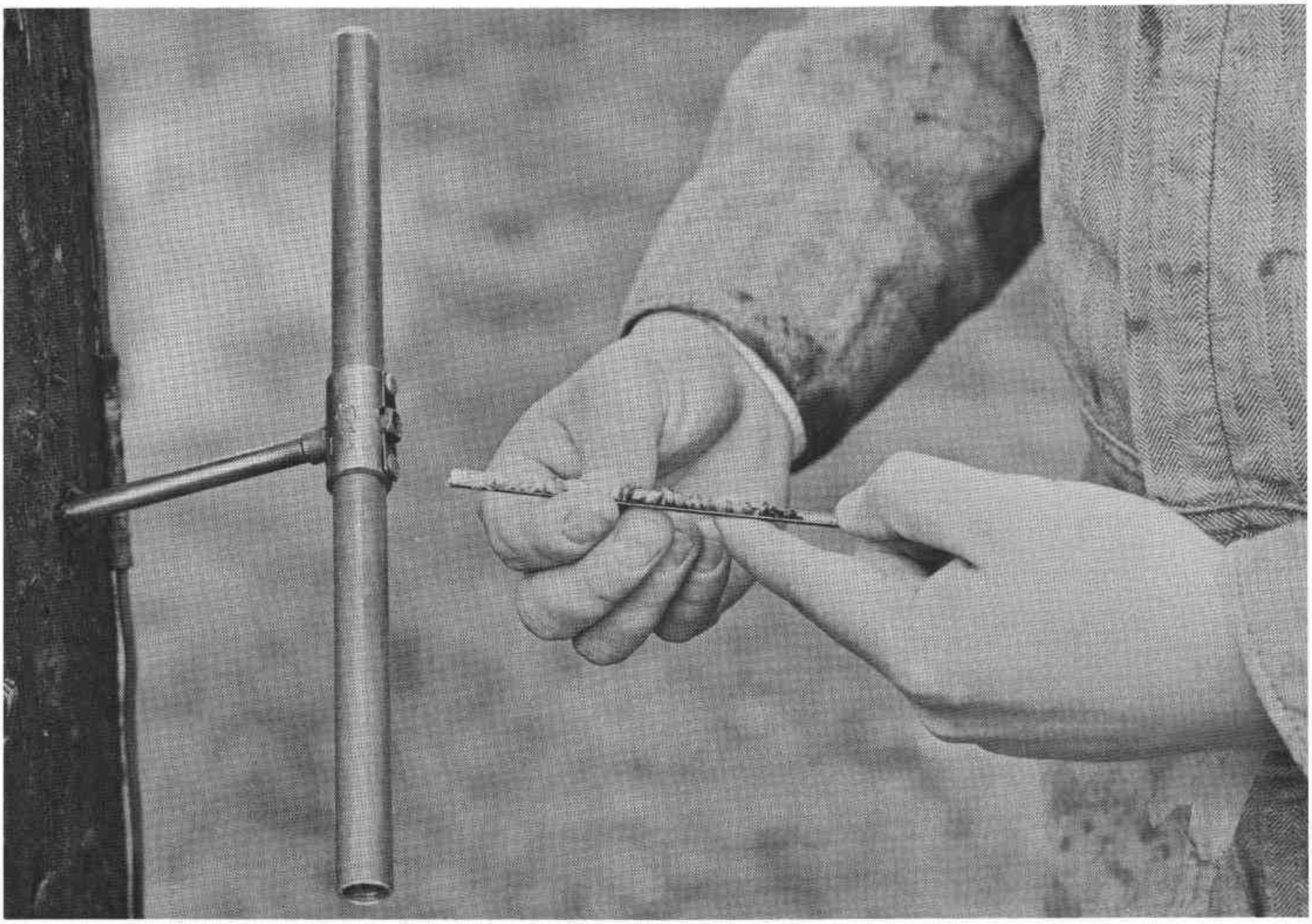


Figure 15.

Cores extracted with an increment borer permit detection of rot, as well as measurement of shell thickness and depth of preservative penetration. Cores can be retained and cultured for fungi.

on the sides for insertion of the extractor) that is chucked in a brace and bit (Fig. 16) or in a variable-speed power drill (Fig. 17). This arrangement works well, but be careful to not damage the bit.

For good cores, be sure to regularly sharpen the bits with a fine hone, especially when cores become twisted and difficult to remove. Some suppliers of increment borers also sharpen bits. Keep the bits free of rust or pitch. To avoid corrosion, keep a small can of machine oil on hand to coat the outside of the bit during use and to coat the inside after use, especially during wet weather. A rifle cleaning kit is handy for cleaning increment borers.

brace and bit

A twist drill 3/8 inch in diameter that is welded to an electrician's bit or an extension rod of slightly smaller diameter permits rapid drilling into poles to well below the groundline. At the groundline, drill downward at a 45° angle towards the center of the pole; above ground, drill holes slightly upwards. An abrupt decrease in drilling resistance indicates rot or a void. Wet wood—especially in cedar poles—and natural voids can falsely suggest rot. During the drilling process, examine wood particles to determine depth of preservative and to note discolored wood and fines indicative of rot.

Figure 16.

Mounting an increment borer bit on an extension for a brace or an electric drill speeds removal of cores.

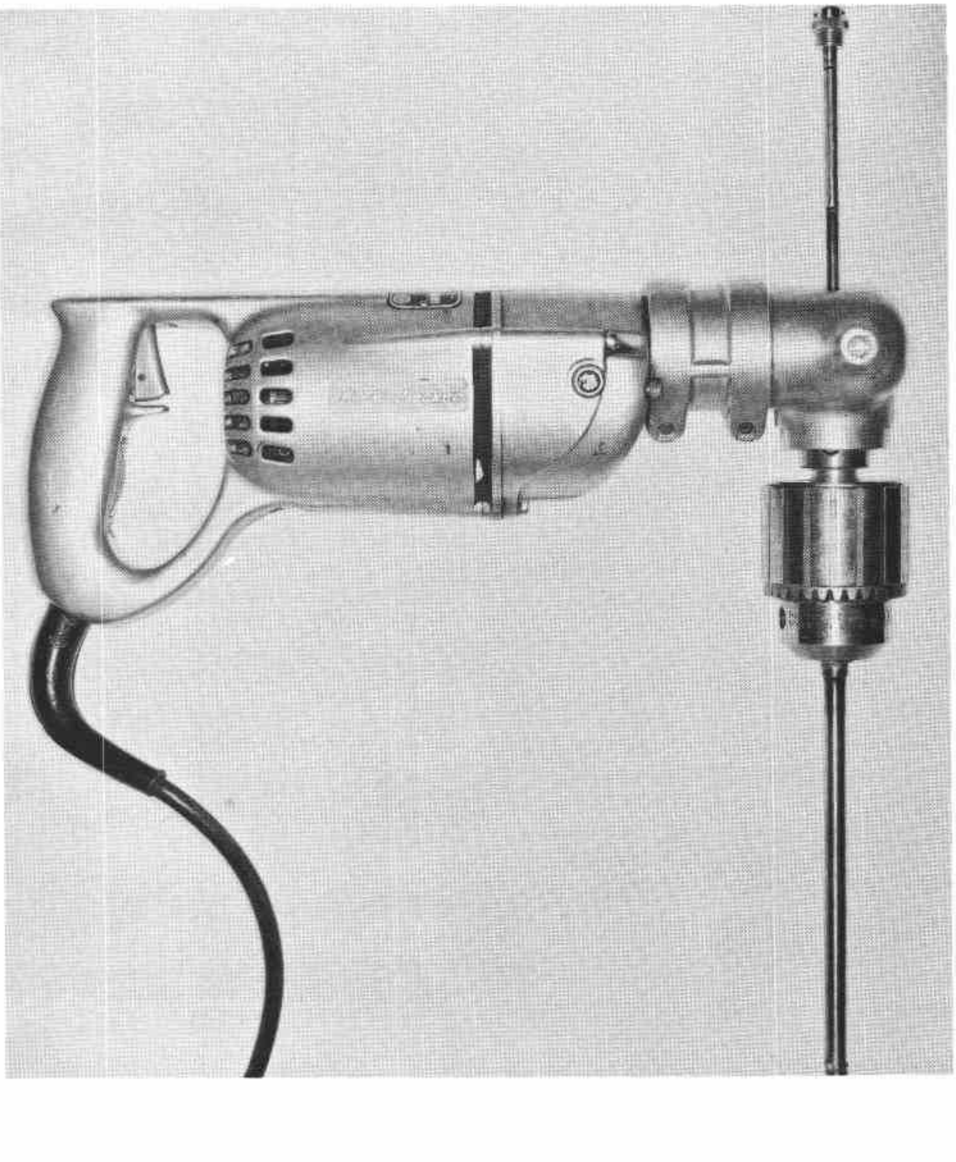


Figure 17.

This increment borer bit, mounted through a 90° speed reducer on a 1/2-inch drill with reverse switch, speeds removal of cores below ground. Photo provided by courtesy of Larry Purpich, Wood Products Laboratory, Public Service Company of Colorado, Denver, Colo.

shell-thickness indicator

To determine the thickness of solid—but not necessarily sound—wood, insert a thin metal rod (Fig. 18) into the hole made by coring or drilling. When the rod is pulled back with pressure against the side of the hole, the hook at the end should catch on the edge of the rot pocket. When pushing a tight fitting shell-thickness indicator into a hole, you can feel the tip of the hook pass from one growth ring to another in solid wood, but not in rotten wood. Inscribe marks on the sides of the rod to indicate the shell thickness at different drilling angles, usually 45° and 90°. This simple, inexpensive device merits further testing.

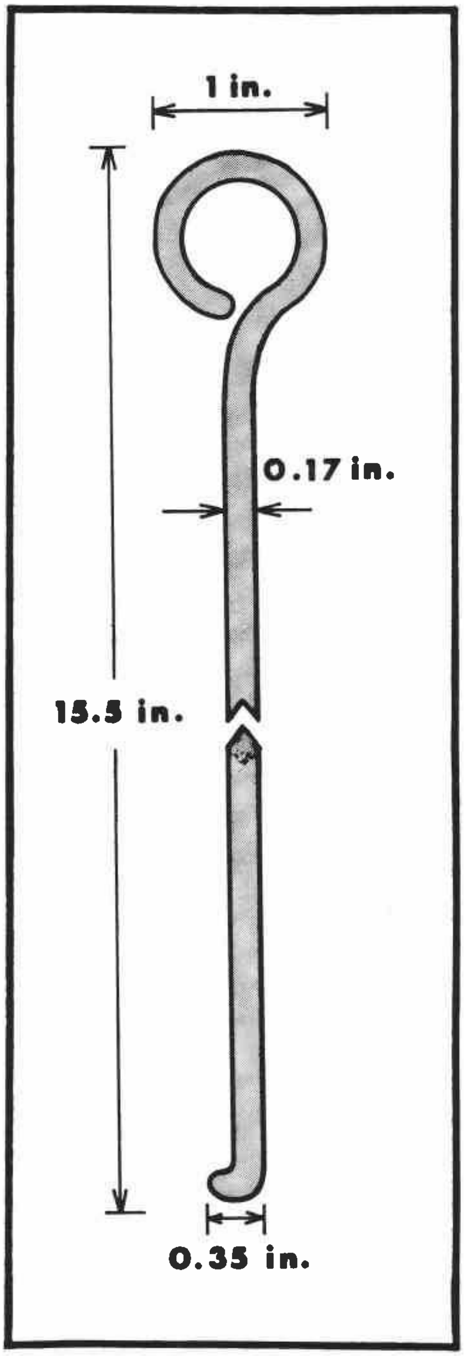


Figure 18.

A shell-depth indicator detects rot in poles by "feeling" growth rings in sound, but not rotten, wood when inserted or removed from snug-fitting holes.

power auger

Poles can be inspected rapidly with an auger 1/2 inch or more in diameter. Drilling resistance changes abruptly when the auger penetrates rotten wood. Chips can be examined. One transmission utility uses a 9/16-inch, single-spur, single-helix, open-centered bit because of its good bite, positive feel, and chip removal. The holes, large enough for treating with fumigant, should be plugged with 5/8-inch plugs. A gasoline-powered chain saw can be converted to a drill with a power take-off gear case adapter.

pol-tek

This sonic testing device (Fig. 19), developed at Detroit Edison Company, supplements conventional inspection procedures. Starting about 6 inches below the groundline, probes are pressed on opposite sides of the pole; a trigger trips a hammer that sends a sound wave down one probe, through the pole, and up the other probe to a dial. A dial reading that is low compared to that of a sound pole of similar diameter indicates rot or another low-density area that delayed the sound wave within the pole. The readings are nearly instantaneous so take several readings on a pole.

The device eliminates the need for making holes in good poles; "bad" poles should be drilled or cored to determine the nature of the defect. Used by trained personnel, Pol-Tek works well on Douglas-fir and western redcedar, but apparently not as well on southern pine poles because of the high incidence of ring shakes. The Pol-Tek should be checked frequently for calibration.

shigometer

Developed for detecting decay in living trees, the Shigometer (Fig. 20) measures electrical resistance (Shigo et al. 1977). It should be used in wood with a moisture content at or above 27 percent which is typical of decaying wood or the groundline of poles. A probe—two twisted, insulated wires with the insulation removed near the tip—is inserted to various depths into a hole 3/32 inch in diameter. A marked change in electrical resistance as the probe goes deeper indicates rot or a defect. The device effectively detects rot, but it also can yield "bad" readings on apparently sound poles. As a precaution, drill or core "bad" poles to determine the nature of the defect. The Shigometer should be used by trained personnel and checked frequently for calibration.

moisture meter

Resistance-type meters (Fig. 21) can be used to detect wood with a moisture content that exceeds 20 percent, the safe limit to prevent decay. Long electrodes can measure moisture to a depth of about 2 1/2 inches. Because the high moisture content of decaying wood—above 25 percent—causes steeper-than-normal moisture gradients in poles decaying internally, the meter becomes a useful tool for determining the extent of decay in poles and other timbers. For example, meter readings above 20 percent and steep moisture gradients indicate the height of decaying wood in Douglas-fir poles with rot below, but not above, the groundline. Similar readings in poles without rot should be suspect. Moisture readings below 20 percent indicate the absence of active decay to the depth of the electrodes.

Check the batteries regularly, and calibrate the meter frequently. Make sure the coating on the shank of the electrodes is intact. When necessary, correct meter readings for ambient temperature as well as wood species.

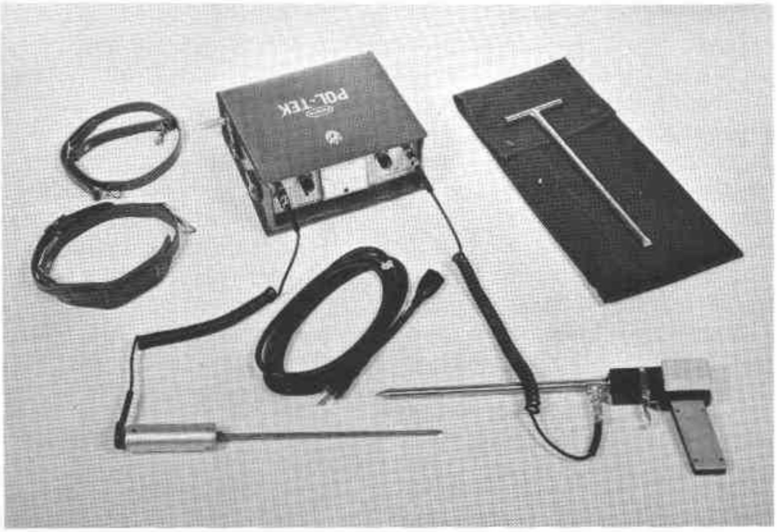


Figure 19.

The Pol-Tek, a sonic device for inspecting poles for rot, detects low density areas in wood. Use an increment borer to determine the nature of the defect.

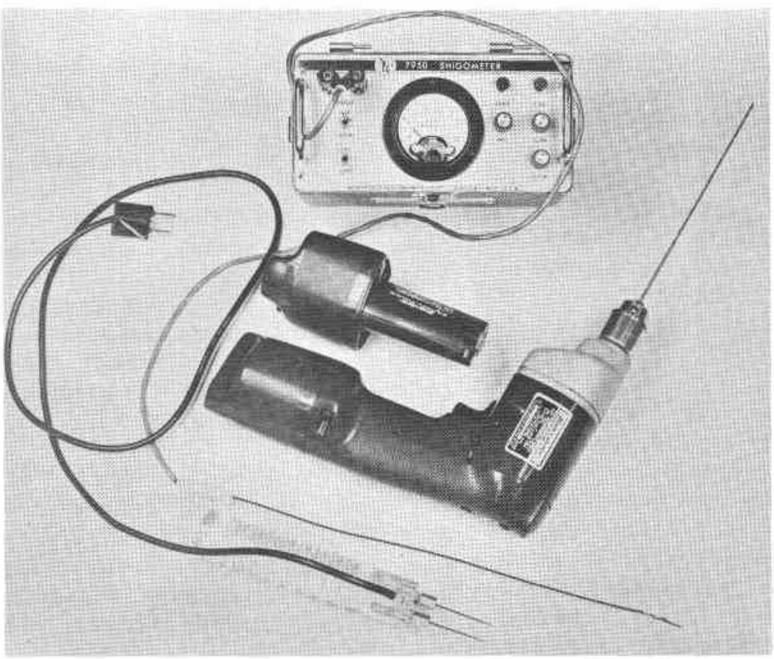


Figure 20.

The Shigometer measures electrical resistance to detect rot in poles. Use an increment borer to determine the nature of the defect.

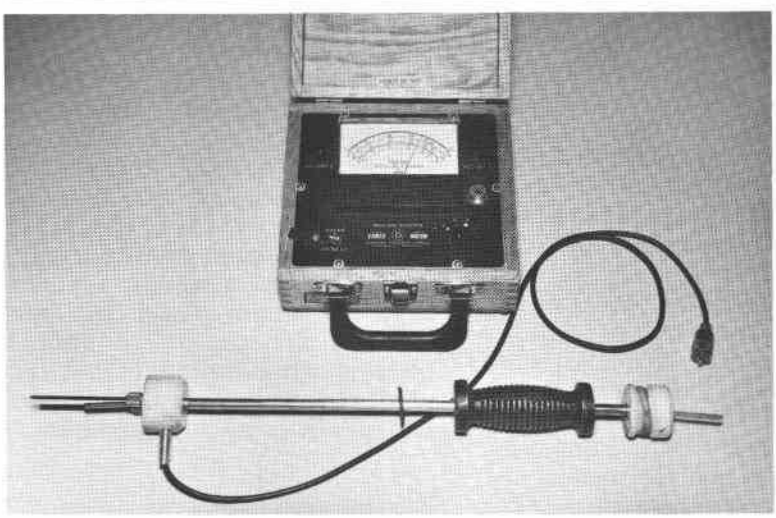


Figure 21.

A resistance-type meter can be useful for detecting moisture contents that are high enough (over 20 percent) for decay. As a sliding hammer drives two electrodes into the wood, a ruler emerging from the top of the hammer measures their depth. Shanks of the electrodes are coated so moisture readings are made between the uninsulated points.

inspecting poles in service

The time and extent of a pole line inspection will vary greatly depending on the inspector's knowledge of the pole system including: the geographic and climatic features of the region; the species and ages of the poles; the type of preservative treatment; and the availability of service records. Lines of mixed-age poles will require more difficult inspection decisions than will lines of even-aged poles.

the initial inspection

By knowing your pole lines, by examining poles in-line or removed from service as the opportunities arise, and by discussing pole maintenance with personnel in other utilities, you can reasonably judge the time for the first inspection. Most importantly, inspect poles early because the goal is to start supplemental treatments at the first sign of degradation, not after poles begin to fail.

Because decay is favored by moist, humid conditions and slowed or prevented by dry or cold conditions, the decay hazard varies throughout the United States and even within a wood pole system. The Climate Index Map (Scheffer 1971), derived from temperature and precipitation data, shows the relative potential throughout the United States for decay of aboveground wood (Fig. 22). The three zones are similar to the decay zones that the Rural Electrification Administration (REA 1974) uses for timing initial and subsequent inspections of poles (Table 2). Although another map (Fig. 23) outlines areas of the continental United States susceptible to subterranean termites (Gjovik and Baechler 1977), no map shows the high dampwood-termite hazard that exists only along the Pacific Coast in the Northwest.

Initially inspecting small groups of poles in selected lines can provide valuable information as a basis for maintenance decisions. Knowing the prevalence of untreated wood in seasoning checks, of insect attack, of early decay, and of surface or internal rot, as well as the depth of preservative penetration and preservative protection remaining in the treated wood below groundline, all help you to determine:

- if additional poles should be inspected,
- if a digging inspection is needed,
- if external treatment is needed, and
- if internal treatment is needed.

Depth of preservative penetration, too often neglected during inspection, can affect decisions on replacement or timing of subsequent inspections. For example, in Douglas-fir, a 2-inch-thick shell of preservative-penetrated wood is far superior to a 2-inch-thick shell of solid wood with 1/2 inch of preservative penetration.

The number of poles sampled in the initial inspection will depend on maintenance practices. Where personnel continually check poles and detect developing problems, the initial sampling inspection may be limited to a relatively small number of poles in certain lines or certain areas. If little is known about a pole system, the inspection could involve a statistical sampling of poles in each line throughout the system. One utility samples "300 poles of a similar age, species, treatment, and by the same manufacturer." REA (1974) generally recommends inspecting "a 1,000 pole sample made up of continuous pole line groupings of 50 or 100 poles in several areas of the system." The percentage of poles

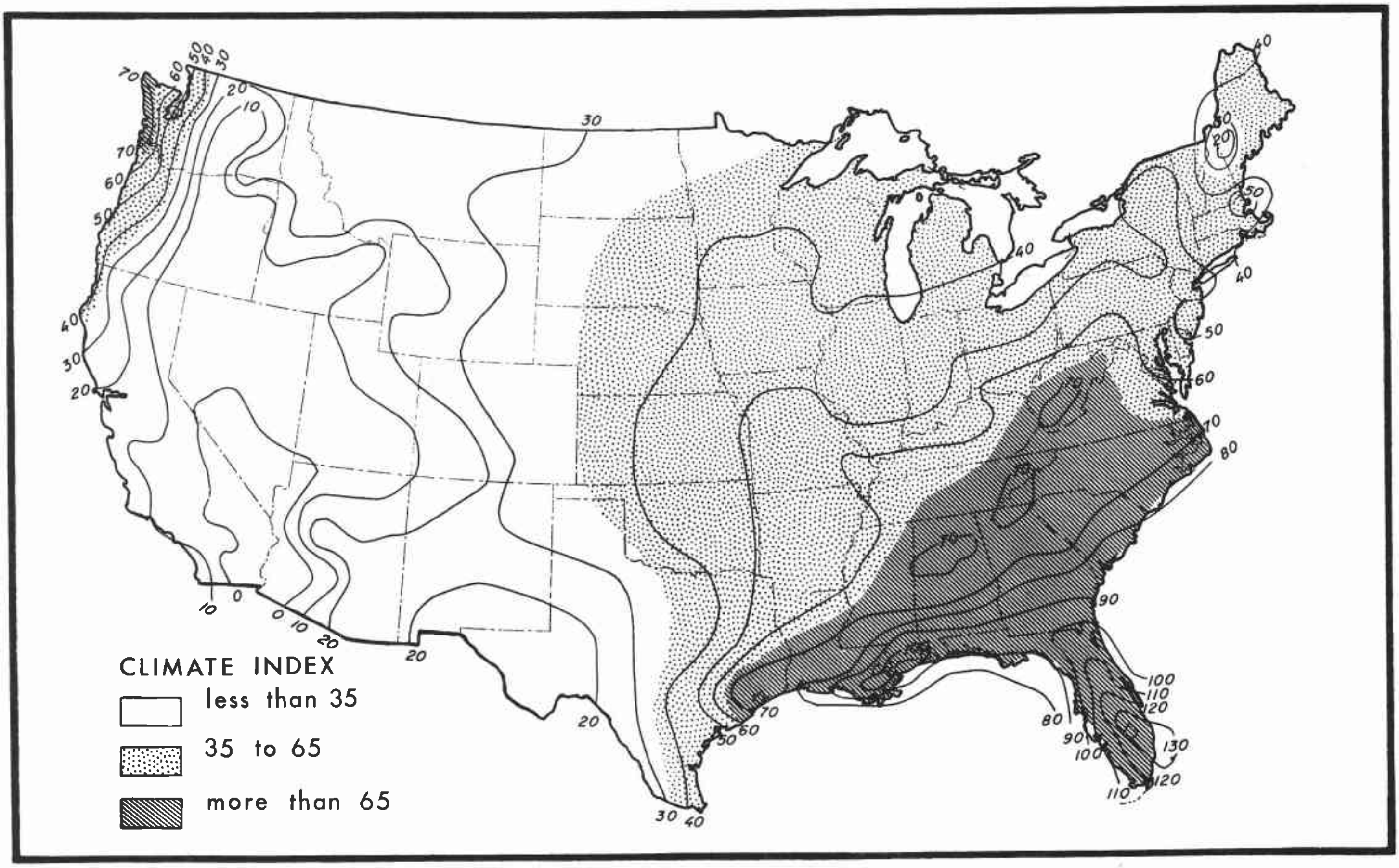


Figure 22.

This climate-index map of the United States provides an estimate of potential for decay of wood above ground (Scheffer 1971).

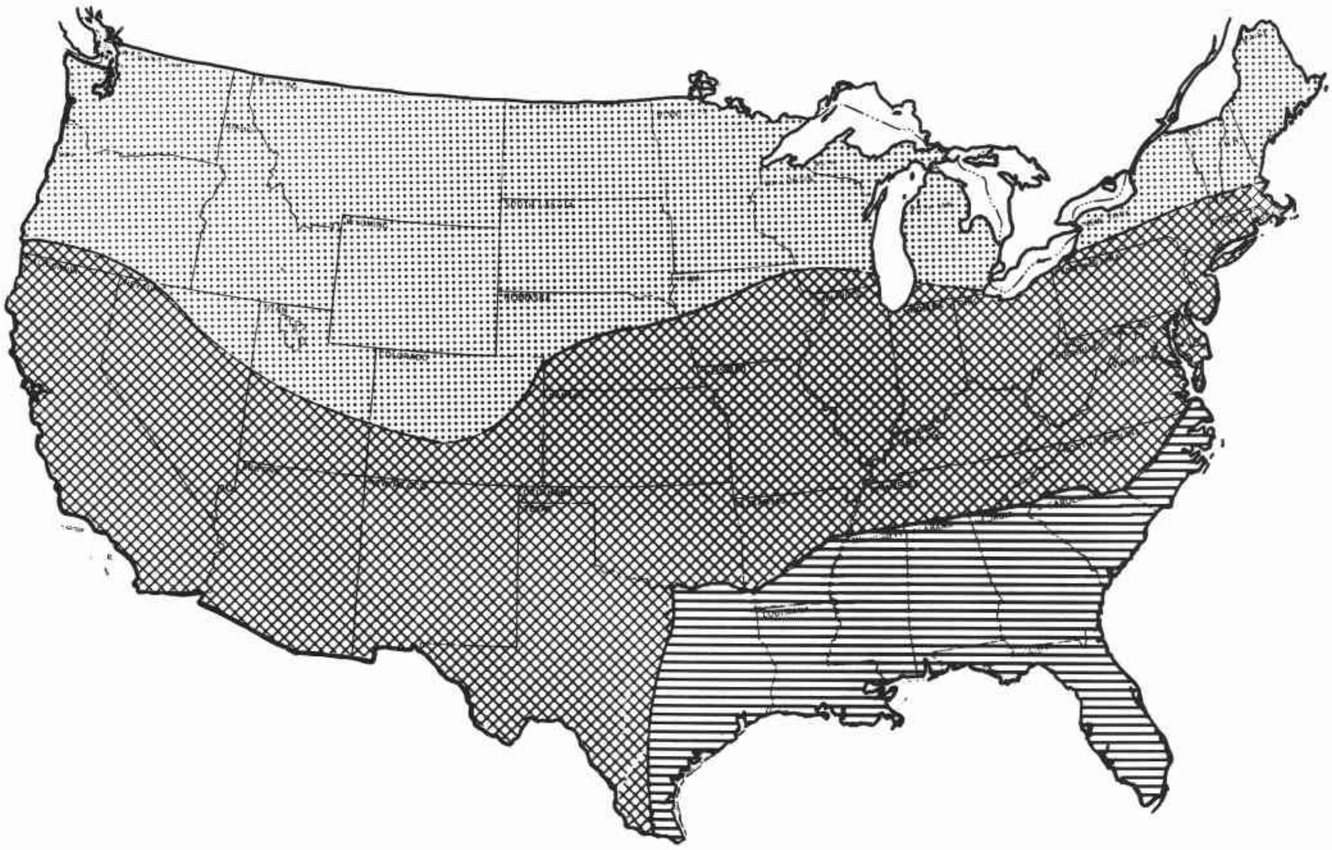
Table 2.

SCHEDULES FOR POLE INSPECTION BY CLIMATE INDEX AND DECAY ZONES[a]

Climate index[b]	Decay zone	Initial inspection (years)	Subsequent reinspection (years)	Poles inspected each year (%)
Less than 35	1	12-15	12	8.3
35-65	2 & 3	10-12	10	10.0
More than 65	4 & 5	8-10	8	12.5

[a]Adapted (except climate index) from REA (1974).

[b]Scheffer (1971).



HIGH HAZARD ZONE (including Hawaii and Puerto Rico). A soil treatment shall be used. In Puerto Rico, all wood materials shall be treated in accordance with 506-2.4a. In Hawaii, all framing lumber in platform-frame construction shall be treated in accordance with 506-2.4a. All treated lumber that is cut after treatment shall have a preservative, recommended by AWPA, applied to cut ends.

MODERATE HAZARD ZONE. Soil treatments generally required. Specific areas may be excepted as determined by HUD field office.

LOW HAZARD ZONE. Soil treatments generally not required except that certain localities may require protection when determined by HUD field office that a hazard exists.

(Courtesy of the Forest Products Laboratory, Madison, Wisconsin)

Figure 23.

This subterranean termite hazard map of the United States provides a guide to potential termite damage in poles (Gjovik and Baechler 1977).

rejected and deteriorating then becomes a basis for decisions on the scope and nature of the pole maintenance program.

caution

Pole inspectors in areas with low hazards of decay or termites should not be complacent. Warm, dry climates are conducive to pole checking. Both surface and internal decay of poles can occur below ground in "dry" areas, along rivers, or in irrigated land. Termites can attack wood anywhere. Metal wraps around butt-treated cedar poles to protect against fire can encourage decay and termite attack of untreated sapwood beneath the wrap.

inspection records

Information stored in an inspector's head is lost when that person leaves or changes jobs. Consequently, you should develop a system for inspecting poles and a concise system for recording and processing that information. The Computer-Aided Wood Pole Maintenance System (Appendix D) provides a rapid, flexible method for storing and processing field data to keep pole records up to date. Printouts provide a current report on the condition of each pole. Using these printouts, maintenance personnel can schedule work so poles are neither lost nor ignored, and managers can facilitate long-range maintenance planning.

to dig or not to dig?

Initial pole inspection should include digging because poles can be sound above the groundline but badly decayed below. As poles age and as poles of new species or with new preservative treatments are installed, do not hesitate to make early digging inspections to find out how the poles are performing. As you become better acquainted with the condition of poles in your system, you can vary the frequency of digging to suit the local conditions.

Digging 18 inches deep will reveal surface decay in most areas, but you may have to dig deeper in dry areas where cedar poles can decay below the incised zone (about 1 foot above to 3 feet below the groundline). One utility found that cedar poles set in gravel decayed "from the butt up." To get the facts, inspect and cut up poles removed from service. Although surface rot is uncommon in pressure-treated Douglas-fir poles, it does occur, so digging is still necessary. Internal pockets of decay can occur well below or above the groundline, depending on local conditions.

to culture or not to culture?

The initial inspection of pole lines of thin-sapwood nondurable-heartwood species should include the culturing of cores for decay fungi. Inspection of Douglas-fir transmission poles installed 10 years earlier revealed only a few poles with internal rot, yet 30 percent of the poles contained decay fungi warranting a program of internal treatment. In western Oregon, for each Douglas-fir pole that contained rot, we found one or two poles that contained decay fungi.

inspecting from the ground

This general procedure for inspecting poles from the gound should be modified to meet the requirements of your pole system.

1. condition of pole above ground

Note the general condition of the pole, unusual damage to the pole or attachments, and the size and location of seasoning checks. In general, the wider the checks, the deeper they penetrate and are more likely to expose untreated heartwood; however, some narrow checks can be very deep.

Look for elliptical holes made by Buprestid beetles, for mounds of sawdust as well as the carpenter ants that make them, and for woodpecker holes.

Examine cedar poles for surface rot and shell rot that are typical of untreated sapwood above the treated butt. Once rare, surface rot below the groundline of pressure-treated Douglas-fir poles seems to be increasing as the result of some new treatments.

2. sounding

Sound the pole from as high as you can reach to the groundline. "Bad" poles usually are easy to detect and, as you gain experience, you will become more proficient in detecting isolated suspicious areas that should be cored or drilled. Sounding alone is a poor inspection procedure that locates only the worst poles.

3. drilling or coring

After sounding, drill or core poles downward at an angle of about 45° at the groundline or slightly upward above ground so that water cannot collect in the holes. Determine shell thickness and depth of preservative treatment.

Poles that sound "good" should be drilled or cored at the groundline or, better yet, one foot below the groundline near or below the widest check.

- **If the wood is solid**, rate the pole as good—until culturing results are available to indicate otherwise.
- **If rot is present**, drill or core the pole at third or fourth points around the circumference. Measure shell thickness, depth of preservative treatment, and pole circumference. From minimum circumference tables such as those used by the REA (1974) but modified for your system, determine if the pole should be replaced, reinforced, left in service and treated to stop the decay, or scheduled for reinspection.

Poles that sound suspicious should be drilled or cored in those areas and near the widest check at or below the groundline.

- **If the shell is inadequate**, schedule the pole for reinforcement or replacement.
- **If the shell is adequate**, remove cores at third or fourth points; based on shell thickness, schedule the pole for replacement, stubbing, supplemental treatment, or reinspection.

4. digging inspection

To check for surface rot, dig the pole out to a depth of 18 inches in wet climates and deeper, if necessary, in dry climates. Brush the pole free of dirt and examine its surface for rot. Probe suspicious areas for soft wood. Scrape the surface with a dull tool or shovel to remove all rotten wood. If in doubt, use the "pick test" (Fig. 14) to check for rot.

To detect internal rot, drill or core the pole below the largest check. If rot is present, determine shell thickness and preservative penetration. Measure the pole circumference after the rot has been removed from the surface. Using the minimum circumference tables, determine if the pole should be scheduled for replacement, given a supplemental treatment, or scheduled for reinspection.

5. holes or cuts made during inspection

Treat all openings made during inspection with a double-strength preservative solution or paste, and plug all holes with preservative-treated dowels because plugs can loosen and fall out. Wear protective goggles because preservative may squirt out of the hole when the plug is driven.

6. treating excavated poles

Preservatives may bleed or leach from poles into the surrounding soil and, in some cases, creosote or pentachlorophenol in heavy petroleum solutions may build up mounds around the pole. Removal of this treated soil during excavation often is considered reason enough for applying an external supplemental treatment to poles with no evidence of surface decay. This may be good for poles with marginal protection, but research has not evaluated this practice.

Many pole managers consider the added cost of such treatment as good insurance that the outer shell of the poles will be protected until the next inspection 8 or more years hence. A policy of groundline-treating all excavated poles removes a difficult decision, especially in lines of mixed-age poles, from the inspector's shoulders and makes such treating a good habit.

On the other hand, if the external shell of a pole is free of rot and well protected by preservative, the additional cost of the groundline treatment is an unnecessary maintenance expense. Chemical analyses (AWPA) or bioassays (Scheffer 1976) of cores or plugs from the treated shell can be made during the initial sampling inspection and periodically thereafter to determine whether excavated poles should be treated.

Do not depend on bleeding or leaching of preservative to protect untreated wood exposed in checks that deepen as poles dry in service.

treating poles in service

External supplemental treatments have long been successfully used to control surface decay in the outer 1 inch of poles. Only recently has internal decay of Douglas-fir poles been successfully controlled by volatile toxicants. Depending on the condition of a pole, it may require an external treatment, an internal treatment, or both. Retreating every 8 to 10 years, or possibly longer (Graham and Corden 1978), should permit poles "decaying" internally to remain in service indefinitely or until they are removed for other reasons.

precautions

- Chemicals used to treat poles in service are potentially toxic to man and can damage the environment unless handled and used properly.
- Use products that have been registered for poles by the U.S. Environmental Protection Agency.
- READ THE LABEL, and follow the prescribed safety precautions and application methods.
- Check with local, state, and federal regulatory agencies about the use and disposal of these chemicals and their containers.
- Personnel applying the chemicals should be "Certified Pesticide Applicators"—check with local, state, and federal regulatory agencies about the required training.

Because of the potential hazards from improper use or accidental spilling or splashing of these chemicals, applicators should:

- Work in pairs.
- Be trained in first aid.
- Wear appropriate protective clothing, usually goggles, gloves, and washable clothing.
- For each chemical in use, have an extra label that can be given to a physician.
- Have readily available
  - Emergency addresses and telephone numbers
  - Washing material (soap and water)
  - Eye rinse.

Vapors of volatile chemicals used to internally treat poles are toxic. However, they also have strong odors that can be detected at very low concentrations, warning of their presence. Heavier than air, vapors released as the chemicals are transferred to small containers may move many feet along the ground before being dispersed or detected. Avoid spilling volatile chemicals on the skin and clothing, especially shoes, because the chemicals can be absorbed through the skin. If chemicals are spilled, evacuate the area until their odors dissipate.

external treatments

Aboveground surface decay of cedar poles can be controlled by flooding the untreated sapwood with pentachlorophenol (usually 10%) in a petroleum oil.

Below ground, bandage treatments minimize environmental contamination yet control surface decay by reinforcing the original preservative treatment. Water-soluble arsenicals and fluorides, alone or mixed with creosote or pentachlorophenol, diffuse into wet wood. They can be brushed on, injected 2 1/2 inches into the wood through a hollow needle at the end of a long lever, or incorporated on or in the wrap. Brushing on a thick coat fills all crevices and assures complete contact betwen preservative and wood. The outer wrap (frequently black polyethylene film) should be durable and extend from slightly above to 18 inches or more below the groundline. Overlap the layers, and fasten the wrap tightly at the top to shed as much water as possible. When backfilling, avoid tearing the wrap.

internal treatments with water-soluble chemicals

Thick solutions of water-soluble chemicals or arsenicals and fluorides can be forced into voids in poles to diffuse through wet wood and control internal rot or insect damage. Success or failure of the treatment depends on the condition of the poles at subsequent inspections. These chemicals are most successful in cedar and other woods with well-defined rot pockets and an abrupt transition from rot to sound wood; they are least effective in Douglas-fir with poorly defined rot pockets. In Douglas-fir poles, commercially applied treatments of a fumigant, alone or combined with a water-soluble solution, are more effective than the solution alone (Graham and Corden 1977).

Volatile liquids such as gasoline combined with creosote or pentachlorophenol have successfully been injected into voids to rid poles of ants.

internal treatments with fumigants

Volatile chemicals—Vapam, Vorlex, and chloropicrin—effectively control internal decay of Douglas-fir poles (Fig. 24) (Graham and Corden 1978).

the chemicals

Trade names for Vapam (sodium N-methyldithiocarbamate) and chloropicrin (trichloronitromethane) are registered with the U.S. Environmental Protection Agency for use on poles. Vorlex (methylisothiocyanate and dichloropropenes) is not registered. Vapam is the most widely used and least obnoxious to handle; however, chloropicrin may remain longer in poles.

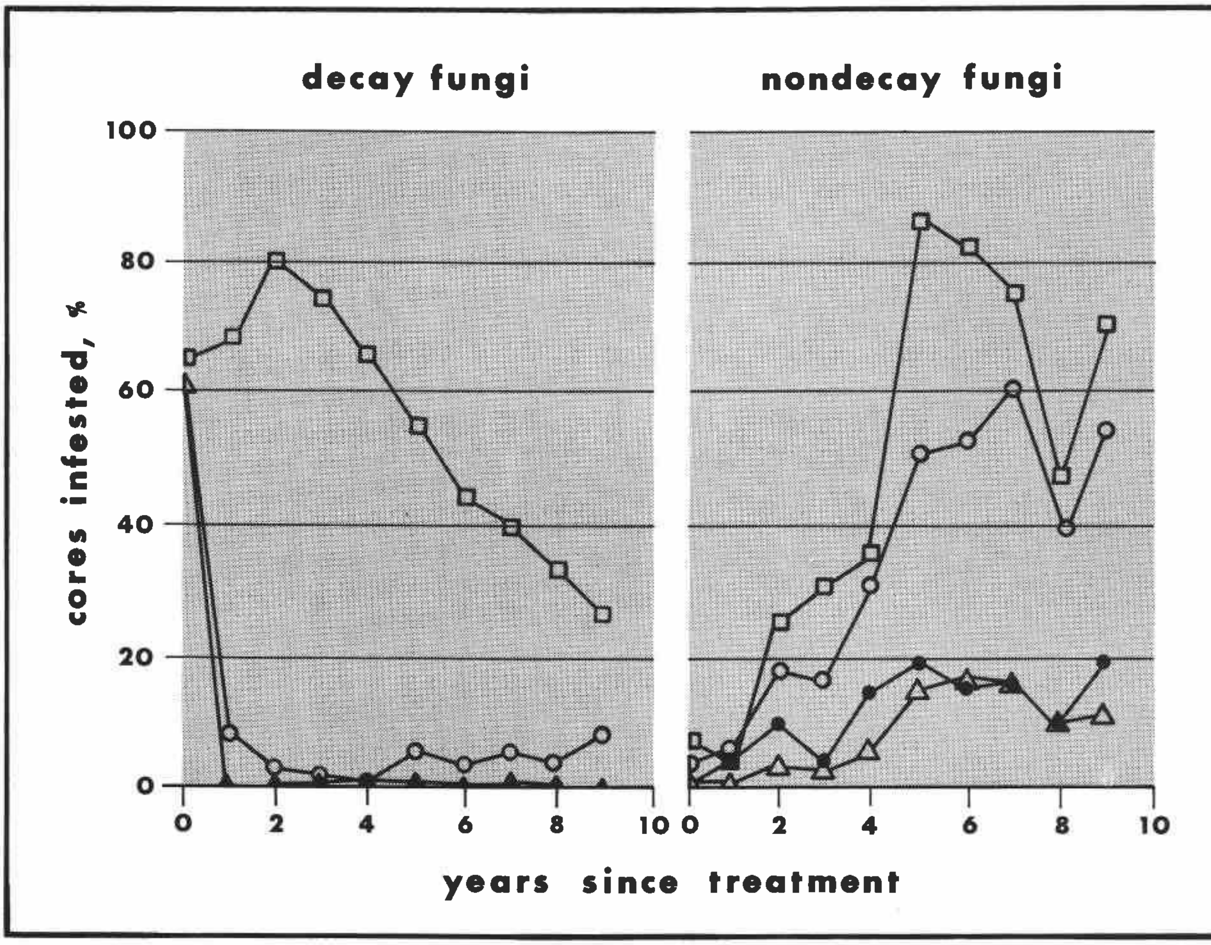


Figure 24.

Fumigants can control internal decay for at least 9 years in transmission poles of pressure-treated Douglas-fir poles. Values are based on 12 cores from each of 8 poles per test group for 4 years and from 5 to 7 poles for later years. Some fumigant-treated poles were inadvertently removed from service.

the process

The liquid fumigant is poured from a 1-pint polyethylene squeeze bottle into holes drilled in the pole. After the holes are plugged, the chemical moves as a gas throughout the wood to about 8 feet above and below the groundline of the poles to eliminate decay fungi and insects.

amount of chemical

For poles with internal rot at the groundline, these amounts of chemical should permit a retreating cycle of 9 years or longer:

Pole circumference	Pints of fumigant
Under 32 inches	3/4
32 to 45 inches	1
Over 45 inches	2

Don't skimp on the amount of chemical used.

drilling holes

Drill a reasonable number of holes to obtain good distribution of the fumigant, but stagger the holes so they do not weaken the pole. Table 3 specifies the number of holes of different diameters and lengths needed to place various amounts of fumigant in poles—note that the hole length allows for the insertion of a 3-inch treated plug. Another utility recommends that the number of holes meet the limits of knot sizes in Table 2 of American National Standard 05.1 (ANSI 1972).

Table 3.

NUMBER OF HOLES REQUIRED IN POLES OF DIFFERENT SIZES TO HOLD VARYING AMOUNTS OF FUMIGANT.

Hole		Fumigant	Holes for poles with circumferences:		
Diameter (inches)	Total length[a] (inches)	(pints per in. of hole)	Less than 32 in. (3/4 pint)	32-45 in. (1 pint)	More than 45 in. (2 pints)
5/8	15	0.010	6	-	-
	18	0.010	5	-	-
3/4	15	0.015	4	6	-
	18	0.015	-	5	-
	21	0.015	-	4	-
	24	0.015	-	3	6
7/8	21	0.024	-	3	5
	24	0.024	-	-	4

[a] Effective length of holes is 3 inches less to allow for a 3-inch treated plug.

Starting at the groundline, drill a hole directly towards the center of the pole at a steep downward angle (Fig. 25) that will avoid going through the pole or through seasoning checks where much of the fumigant could be lost. If the hole intersects a check, plug that hole and drill another. Equally space the remaining holes around the pole upward in a spiral pattern with a vertical distance of 6 to 12 inches between holes. If more than two treating holes intersect an internal void or rot pocket, redrill the holes further up the pole into relatively solid wood where the fumigant will gradually volatilize and move through the wood. Much of the fumigant placed in rot pockets will be lost if the seasoning checks connect. Where a rot pocket is above the

Figure 25.

Drill fumigant-treating holes downward at a steep angle towards the center of the pole to avoid crossing seasoning checks.

groundline, drill holes in solid wood below the pocket as well as above.

applying fumigant

Wearing protective clothing and standing upwind, slowly squeeze the chemical into the lowest hole first. Pour only the prescribed amount of chemical into the hole to leave space for the plug. Insert a tight-fitting treated plug, preferably of Douglas-fir or other wood of low permeability. Drive the plug in carefully so fumigant does not squirt from the hole. Working up the pole, fill and plug the other holes.

Instead of cutting the top off the plastic cap on the squeeze bottle, use an interchangeable cap fastened to a 1-foot length of tubing. The tubing helps you control the filling operation and the amount of chemical placed in the pole (Fig. 26). Replacing the original cap seals the remaining liquid in the bottle.

Maintenance Standard 15-6 of the British Columbia Hydro and Power Authority[1] details construction of a dispenser that attaches to a pressure-type garden sprayer for placing Vapam in poles.

retreating

Although decay fungi will reinvade some Vapam-treated poles in about 5 years, the fungal population remains low for at least 9 years (Fig. 24). Vapam-treated

[1] For details, contact J. S. Gardner, 800-1045 Howe St., Vancouver, B.C. Canada V6Z 2B1.

Figure 26.

Tubing attached to a 1-pint polyethylene squeeze bottle provides good control of the amount of fumigant placed in holes.

poles should be retreated every 9 years by replacing Vapam in the same holes. Because poles treated with chloropicrin and with Vorlex have remained virtually free of decay fungi for 8 years, retreatment may be delayed 10 or more years.

When to retreat fumigant-treated poles is not easy to determine. Measurements of shell thickness vary because of the irregular pattern of rot in poles. However, consistent reduction at 8- to 10-year intervals in shell thickness of poles would indicate the need for retreatment.

A more reliable approach is to establish groups of 20 decaying poles which are cored before treatment with fumigants and thereafter every 5 years. The cores should be measured for shell thickness, then cultured (Appendix B) for the presence of decay fungi.

Small sensing elements now being developed show promise for easily and quickly determining when poles should be treated—when placed in poles, these elements measure changes in electrical resistance as the fumigant concentration decreases. Research now is evaluating the effectiveness of these and other methods for determining the presence and concentration of fumigants in poles.

poles set in concrete

During inspection, some utility companies are applying fumigants to all poles set in concrete as insurance against the high cost of their conventional supplemental treatment or replacement. Extra precautions should be taken to make sure that the chemical does not spill, that treating holes do not cross seasoning checks, and that plugs are tightly driven. If leaks do occur, wrapping the lower 3 or 4 feet of the pole with polyethylene may eliminate the odor.

reinforced poles

Fumigants also are being used to stop decay in reinforced poles. Locate treating holes above the decay pocket and in solid wood to make sure that wood beneath the bands retains its strength. By stopping decay, fumigants eliminate the need for cutting off poles at the groundline—this way, the strength remaining in the pole can be utilized.

decay of poles above ground

Failure to adequately protect cuts or holes made in poles, exposure of untreated wood as seasoning checks deepen, and woodpecker holes can lead to decay in poles above ground. Exposed tops and bolt holes can be protected by applying preservatives during line construction, but woodpecker holes and seasoning checks make decay more difficult to control. End grain exposed in the hole permits rapid penetration of water and equally rapid invasion by decay fungi. Applying water-soluble preservatives in woodpecker holes and filling the holes to keep out water might stop further decay.

Untreated wood exposed in checks often is difficult to detect. Flooding checks with preservative not only is expensive, but it also is unlikely to protect those deep, narrow slits where protection is needed most. Fortunately, most checks drain rapidly and side grain exposed in checks does not absorb water easily. As part of the pole maintenance program, poles should be climbed and cored near the base of seasoning checks, especially where checks terminate above knots and water is most likely to collect. Fumigants are the only way to stop such decay, but—as emphasized earlier—extra precautions should be taken to protect workers applying the chemicals. Workers should fill and plug the lowest hole first, remaining upwind and above the hole as they work up the pole. The hazards of treating poles above ground will be greatly reduced if solid chemicals that change directly to gases work as effectively in poles in service as they have in wood-block laboratory tests (Graham and Corden 1978).

As a well-trained inspector, you play a vital role in the maintenance of wood poles because the serviceability and safety of the wood pole system rests upon your decisions.

Early recognition of deteriorating poles before they begin to fail signals the need for supplemental treatments that can control both external and internal decay of poles. Wisely used, these treatments can save human lives, increase the service life of poles without unnecessary hazard to humans or the environment, and reduce maintenance costs.

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JAMES, W. L. 1976. Effects of wood preservatives on electric moisture meter readings. U.S. For. Prod. Lab., Madison. Res. Note FPL-0106. 20 p.

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MILLER, D. J., and R. D. GRAHAM. 1963. Treatability of Douglas-fir from the western United States. Proc. Am. Wood-Preservers' Assoc. 59:218-222.

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SCHEFFER, T. C. 1971. A climate index for estimating potential for decay of wood structures above ground. For. Prod. J. 21:25-31.

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SHIGO, A. L., W. C. SHORTLE, and J. OCHRYMOWYCH. 1977. Detection of active decay at groundline in utility poles. U.S. For. Serv., Northeastern For. Exp. Stn., Upper Darby, Penn. Gen. Tech. Rep. NE-35. 26 p.

appendix A
wood and its preservation: sele

This list of reference materials developed as an outgrowth of numerous workshops held for groups of major consumers and producers of treated wood products that are used in adverse environments. The references are listed alphabetically by title for eight topics: wood, wood seasoning, wood deterioration, wood preservation, maintenance, specifications, service records, and buildings. Because several items are available from the same source, we've listed eight sources and shown the corresponding numbers with the citations. Sources for other items are included with the citations.

sources

1 American Wood-Preservers' Institute
1651 Old Meadow Road
McLean, Virginia 22101

2 Eastern Forest Products Laboratory
Department of the Environment
Montreal Road
Ottawa, Ontario, Canada K1A OW5

3 Superintendent of Documents
U.S. Government Printing Office
Washington, D.C. 20402

4 Forest Research Laboratory
School of Forestry
Oregon State University
Corvallis, Oregon 97331

5 Extension Service
Oregon State University
Corvallis, Oregon 97331

6 U.S. Forest Products Laboratory
P.O. Box 5130
Madison, Wisconsin 53705

7 Western Forest Products Laboratory
Department of the Environment
6620 Northwest Marine Drive
Vancouver, B.C., Canada V6T 1X2

8 Forestry Media Center
School of Forestry
Oregon State University
Corvallis, Oregon 97331

wood

-- **Canadian wood, their properties, and uses.** 1951. 367 p. About $3.

Published by: Controller of Stationery, Ottawa, Canada.

7 **Chemical color tests for Canadian woods.** 1973. By G.M. Barton. Free.

6 **Classroom demonstrations of wood properties.** 1969. By A.N. Foulger. PA-900. Free.

6 **Sapwood thickness of Douglas-fir and five other western woods.** 1969. By L.E. Lassen and E.A. Okkonen. Res. Pap. 124. 16 p. Free.

-- **Textbook of wood technology, third edition.** 1970. By A.J. Panshin and C. deZeeuw. 705 p. About $25.

This excellent book covers formation, anatomy, properties, and identification of wood. Published by: McGraw-Hill, Inc., 8171 Redwood Highway, Novato, Calif. 94947.

-- **Western woods use book.** 1973. 316 p. About $10.

This book includes structural data and design tables, with chapters on wood preservation and fire protection. Published by: Western Wood Products Association, 1500 Yeon Building, Portland, Oreg. 97204.

3 **Wood handbook.** 1974. U.S. Dep. Agric., Handb. 72. 421 p. About $8.

This is an invaluable storehouse of information about wood.

8 **Wood structure.** Undated. By Robert L. Krahmer. $15 to rent, $90 to purchase.

This slide-tape package (114 slides, 35 minutes) details the anatomy of wood, how preservatives are retained, and why wood shrinks and swells.

seasoning

3 **Air drying of lumber: a guide to industry practices.** 1971. By Raymond C. Rietz and Rufus H. Page. U.S. Dep. Agric. Handb. 402. 110 p. About $1.

3 **Dry kiln operators manual.** 1961. U.S. Dep. Agric. Handb. 188. 197 p. About $3.

This is an excellent reference on wood drying.

6 **Effects of wood preservatives on electric moisture meter readings.** 1976. By W. L. James. Res. Note FPL-0106. 20 p. Free.

6 **Electric moisture meters for wood.** 1975. By W. L. James. Gen. Tech. Rep. FPL-6. 27 p. Free.

-- **High temperature drying and its effects on wood.** 1969. By M. Salamon. For. Prod. J. 19:27-34.

-- **High-temperature drying of lumber—a review.** 1968. By David P. Lowery, John P. Krier, and Robert A. Hann. Res. Pap. INT-48. 10 p. Free.

Published by: Intermountain Forest and Range Experiment Station, U.S. Forest Service, Ogden, Utah 84401.

8 **How wood dries.** Undated. By Leif D. Espenas and Robert D. Graham. $15 to rent, $80 to purchase.

This slide-tape package (76 slides, 30 minutes) details the relationship of fiber walls to the swelling and shrinking of wood, the movement of water through wood, and how moisture changes affect wood.

4 **Kiln and Boulton-drying Douglas-fir pole sections at 220° to 290°F.** 1972. By R. D. Graham and R. J. Womack. For. Prod. J. 22:50-55.

7 **Kiln drying of western Canadian lumber.** 1976. By G. Bramhall and R. W. Wellwood. Info. Rep. VP-X-159. 112 p. Free.

Excellent.

6 **List of publications on wood drying.** 1976. 12 p. Free.

7 **Portable electric moisture meters for quality control.** 1971. By M. Salamon. Info. Rep. VP-X-80. 36 p. Free.

deterioration

decay and stain fungi

-- **Forest pathology.** 1938 (revised 1961). By J. H. Boyce. 600 p. About $20.

Published by: McGraw-Hill Book Company, Inc., New York, N.Y.

6 **Fungi associated with principal decay in wood products in the United States.** 1965. By C. G. Duncan and F. F. Lombard. Res. Pap. WO-4. 31 p. Free.

7 **Prevention of sap stain and mold in packaged lumber.** 1974. By J. W. Roff, A. J. Cserjesi, and G. W. Swann. Publ. 1325. 41 p. Free.

4 **Staining of wood and its prevention.** 1964. By R. D. Graham and D. J. Miller. Spec. Rep. 2. 10 p.

6 **Stains of sapwood and sapwood products and their control.** 1940. By T. C. Scheffer and R. M. Lindgren. Tech. Bull. 714. 124 p. Free.

6 **Utility pole decay, Part II: Basidiomycetes associated with decay in poles.** 1970. By W. E. Eslyn. Wood Sci. Tech. 4:97-103.

insects

5 **Carpenter ant control.** 1971. By R. L. Goulding and Joseph Capizzi. Ext. Circ. 627. 5 p. Free.

3 **Controlling wood destroying beetles in buildings and furniture.** 1973. By Harmon R. Johnston and Lonnie H. Williams. U.S. Dep. Agric., Leaflet 558. 8 p. Stock No. 001-000-02895-2. About $0.35.

5 **Dampwood termite control.** 1973. By R. L. Goulding and R. W. Every. Ext. Circ. 700. 5 p. Free.

-- **Recognition and control of wood destroying beetles.** 1973. By L. H. Williams. 15 p. Free.

Published by Southern Forest Experiment Station, P.O. Box 2008, Gulfport, Miss. 39503.

3 **Subterranean termites—their prevention and control in buildings.** 1960. By R. J. Kowal, R. H. Johnston, and R. A. St. George. Home and Garden Bull. 64. 30 p. Stock No. 001-000-03459-6. About $0.50.

-- **Termites and termite control.** 1934. Edited by C. A. Kofoid. 734 p.

This out-of-print book is a source of extensive information on termites. Published by: University of California Press, Berkeley.

5 **The golden Buprestid—a wood boring beetle.** 1962. By Robert W. Every and J. A. Rudinskv. Ext. Circ. 713. 4 p. Free.

3 **Western forest insects.** 1977. By R. L. Furniss and V. M. Carolin. U.S. Dep. Agric., Misc. Publ. 1339. 654 p. Stock No. 001-000-03618-1. About $9.

marine borers

-- **Marine borers and their relation to marine construction on the Pacific Coast: final report of the San Francisco Bay Marine Piling Committee.** 1927. By C. L. Hill and C. A. Kofoid. 357 p.

This out-of-print book, published by the University of California Press (Berkeley), is a classic on marine borers.

7 **Marine borers and wooden piling in British Columbia waters.** 1966. By S. Bramhall. Dep. Forestry Publ. 1138. 68 p. Free.

-- **Marine boring and fouling organisms.** 1959. By Dixy Lee Ray. 536 p. About $9.

Published by: University of Washington Press, Seattle, Wash.

general

8 **Wood destroyers in the marine environment.** Undated. By Robert D. Graham, Guy Helsing, and Jonathan D. Lew. $15 to rent, $80 to purchase.

This slide-tape package (75 slides, 15 minutes) describes the organisms involved in marine wood deterioration, the nature of their attack on wood, and conditions that favor their development.

preservation

-- **A guide to establishing a pressure-treating plant for small sawed and round wood products in Colorado.** 1971. By K. Kilborn. 50 p. Free.

Published by: Department of Forest and Wood Sciences, Colorado State University, Fort Collins, Colo. 80521.

4 **Anatomical features of permeable and refractory Douglas-fir.** 1961. By R. L. Krahmer. For. Prod. J. 11:439-441. Free.

-- **Annotated bibliography on prevention and control of decay in wooden structures (including boats).** 1971. By T. L. Amburgey. 123 p. Free.

Published by: Southern Forest Experiment Station, P.O. Box 2008, Gulfport, Miss. 39503.

-- **Decay of timber and its prevention.** 1950. By K. S. G. Cartwright and W. P. K. Findlay. 294 p.

Published by: Chemical Publishing Co. Inc., New York, N.Y.

-- **Deep treatment of Douglas-fir poles.** 1969. By C. W. Best and G. E. Martin. Proc. Am. Wood-Preservers' Assoc. 65:223-226.

4 **Effect of incising and saw kerfs on checking of pressure-treated Douglas-fir spar crossarms.** 1966. By R. D. Graham and E. M. Estep. Proc. Am. Wood-Preservers' Assoc. 62:155-158. Free.

-- **Field test of deeply incised treated Doulgas-fir poles.** 1969. By E. H. Grassel. Rep. LR-19412. Free.

Published by: Branch of Laboratories, Bonneville Power Administration, P.O. Box 491, Vancouver, Wash. 98660.

-- **Field tests of relative strength of incised fir poles.** 1961. By D. L. Brown and D. F. Davidson. Free.

Published by: Portland General Electric Co., 621 Southwest Alder Street, Portland, Oreg. 97205.

6 **List of publications on fire performance of wood.** 1971. 4 p. Free.

6 **List of publications on wood preservation.** 1974. 9 p. Free.

-- **Location of pentachlorophenol by electron microprobe and other techniques** in cellon-treated Douglas-fir. 1971. By H. Resch and D. G. Arganbright. For. Prod. J. 21:38-43.

-- **On the antiseptic treatment of timber.** 1884. By S. B. Boulton. Minutes of Proc., Institution of Civil Engineers (London) 78:97-211.

This wood preserver's "gem" is well worth the search.

8 **Penetration of liquids into wood.** Undated. By Richard T. Lin, Donald J. Miller, and Robert D. Graham. $15 to rent, $85 to purchase.

This slide-tape package (80 slides, 20 minutes) covers theoretical aspects of fluid flow as related to the treating process, movement of preservatives through wood, and practical aspects of preservation.

-- **Preservative treatment of wood by pressure methods.** 1952. By J. D. MacLean. U.S. Dep. Agric. Handb. 40. 160 p.

Although this book is out of print, it is an excellent reference if you can get a copy.

4 **Pressure treatment and strength of deeply perforated Pacific Coast Douglas-fir poles.** 1969. By R. D. Graham, D. J. Miller, and R. H. Kunesh. Proc. Am. Wood-Preservers' Assoc. 65:234-241. Free.

8 **Pressure wood-preserving processes.** Undated. By Robert D. Graham. $15 to rent, $90 to purchase.

This slide-tape package (119 slides, 24 minutes) discusses the uses of pressure-treated wood, how wood is prepared for treating, and how the treating processes work.

7 **Prevention of sap stain and mold in packaged lumber.** 1974. By A. J. Cserjesi, J. W. Roff, and G. W. Swann. Publ. 1325. 43 p. Free.

7 **Protection and preservation of wood in service: questions and answers.** 1975. By J. W. Roff, R. S. Smith, A. J. Cserjesi, and P. A. Cooper. Info. Rep. VP-X-145. 42 p. Free.

-- **Resistance of timbers to impregnation with creosote.** 1971. By L. W. Redding. Bull. 54. 43 p.

For timber from many nations. Her Majesty's Stationery Office, London, England.

-- **Results of preservative treatment of Douglas-fir from different areas.** 1961. By J. O. Blew, Jr. Proc. Am. Wood-Preservers' Assoc. 57:200-212.

4 **Saw kerfs reduce checking and prevent internal decay in pressure-treated Douglas-fir poles.** 1976. By Guy Helsing and R. D. Graham. Holzforschung 30:184-186. Free.

-- **Strength and related properties of wood poles: final report.** 1960. By L. W. Wood, E. C. O. Erickson, and A. W. Dohr. 83 p.

Published by: American Society for Testing and Materials, 1916 Race St., Philadelphia, Penn. 19103.

6 **Study of the preservative treatment of lumber.** 1955. By J. O. Blew, Jr. Rep. 2045. 40 p. Free.

4 **Treatability of Douglas-fir from western United States.** 1963. By D. J. Miller and R. D. Graham. Proc. Am. Wood-Preservers' Assoc. 59:218-222. Free.

-- **Wood deterioration and its prevention by preservative treatments. Volume 1—Degradation and protection of wood. Volume 2—Preservatives and preservative systems.** 1973. By D. D. Nicholas, ed. 402 p. (both volumes combined). About $20 for Vol. 1, $22 for Vol. 2.

These volumes, detailed analyses of available knowledge by 17 authors, include numerous references plus recommendations for future research. Published by: Syracuse University Press, Syracuse, N.Y. 13210.

-- **Wood preservation during the last 50 years.** 1951. By H. B. Van Groenou, H. W. L. Rischen, and J. Van Den Berge. 318 p.

Published by: A. W. Sijthoff's Uitgeversmaatschappij N. V., Leiden (Holland).

8 **Wood preservation microcourse.** Undated. By Robert D. Graham. $15 to rent, $80 to purchase.

This slide-tape package (80 slides, 22 minutes) briefly explains the principal concepts of the structure, drying, and pressure treating of wood.

8 **Wood preservation minicourse.** Undated. By Robert D. Graham. $15 to rent, $100 to purchase.

This slide-tape package (144 slides, 50 minutes) provides a condensed explanation of wood structure, how wood dries, penetration of preservatives into wood, and pressure wood-preserving processes.

maintenance

-- **A climate index for estimating potential for decay of wood structures above ground.** 1971. By T. C. Scheffer. For. Prod. J. 21:25-31.

-- **A guideline for the physical inspection of poles in service.** 1972. Standard M12-72. 2 p.

Published by: American Wood-Preservers' Association, 1625 Eye St., N.W. Washington, D.C. 20006.

-- **A sonic method for detecting decay in wood poles.** 1967. By B. D. Miller, F. L. Taylor, and R. A. Popeck. Proc. Am. Wood-Preservers' Assoc. 61:109-113.

4 **Applicability of radiography to inspection of wood products.** 1965. By J. S. Mothershead and S. S. Stacey. P. 307-336 *in* Proc. Second Symposium on Nondestructive Testing of Wood. 243 p. Free.

Published by: Washington State University, Pullman, Wash. 99163.

-- **Bioassay estimation of protection in spray treated western redcedar poles.** 1973. By R. D. Graham and T. C. Scheffer. For. Prod. J. 23:106-109.

4 **Bioassay of residual preservative protection in wood.** 1976. By T. C. Scheffer and J. D. Lew. For. Prod. J. 26:45-50. Free.

-- **Controlling biological deterioration of wood with volatile chemicals.** 1977. By R. D. Graham and M. E. Corden. Electric Power Institute EL-366 Project: 212-1, Interim Rep. 1. 61 p. About $4.

This report comprehensively reviews current wood preservation research in progress at the Forest Research Laboratory at Oregon State University and lists pertinent references. Published by: Research Reports Center, P.O. Box 10090, Palo Alto, Calif. 94303.

6 **Decay in wood bridges: inspection and preventive and remedial maintenance.** 1977. By J. W. Clark and W. E. Eslyn. 51 p. Free.

-- **Detection of active decay at groundline in utility poles.** 1977. By A. L. Shigo, W. C. Shortle, and J. Ochrymowych. Gen. Tech. Rep. NE-35. 26 p. Free.

Published by: Northeastern Forest Experiment Station, U.S. Forest Service, 6816 Market St., Upper Darby, Penn. 19082.

4 **Field procedure for detecting early decay.** 1966. By J. L. Ricard and J. S. Mothershead. For. Prod. J. 16:58-59. Free.

2 **Five year performance of slow release type ground line preservatives in creosoted pine poles.** 1972. By J. Krzyzewski. Info. Rep. OP-X-44. 14 p. Free.

-- **Fumigants control decay in wood poles.** 1977. By R. D. Graham. Electrical World, Transmission/Distribution, April 15. p. 53-54.

4 **Fumigants control wood piling decay.** 1976. By R. D. Graham, G. Helsing, and J. D. Lew. World Ports/American Seaport 39:18-19. Free.

2 **In-service assessment of load capacity, decay and retreatment of utility poles.** 1976. By J. W. Roff and J. Krzyzewski. Rep. OPX45E. 11 p. Free.

4 **Inspecting and treating western redcedar and Douglas-fir poles in service.** 1967. By R. D. Graham and J. S. Mothershead. Info. Circ. 21. 34 p. Free.

4 **Inspection and treatment of poles in service—a survey.** 1962. By John S. Mothershead and Robert D. Graham. Rep. P-6. 63 p. Free.

-- **Marine biology operational handbook—inspection, repair, and preservation of waterfront structures.** 1965. By the U.S. Dept. of the Navy. NAVDOCKS MO-311.

Published by: Bureau of Yards and Docks, Washington, D.C. 20390.

-- **Methods for inspection of standing poles in overhead lines.** 1959. By Transmission and Distribution Committee. 20 p. About $1.50.

Published by: Edison Electric Institute, 90 Park Ave., New York, N.Y. 10016.

-- **Pole inspection and maintenance.** 1974. By the Rural Electrification Administration. Bull. 161-4. 50 p. Free.

Published by: REA, U.S. Department of Agriculture, Washington, D.C. 20250.

-- **Port maintenance.** 1970. 224 p. About $15.

Published by: The American Association of Port Authorities, Inc., Washington, D.C.

4 **Preventing and stopping internal decay of Douglas-fir poles.** 1973. By R. D. Graham. Holzforschung 27:168-173. Free.

8 **Preventing and stopping internal decay of poles.** Undated. By R. D. Graham and T. C. Scheffer. $15 to rent, $80 to purchase.

This slide-tape package (80 slides, 30 minutes) discusses factors that contribute to the internal decay of poles. It also shows practices to prevent internal decay in new poles and to stop internal decay of poles in service.

6 **Study of groundline treatments applied to five pole species.** 1961. By E. Panek, J. O. Blew, Jr., and R. H. Baechler. Rep. 2227. 12 p. Free.

-- **The remedial treatment of telephone and electric transmission poles.** 1967. By D. H. Smith and R. Cockroft. Wood (England), September-November. 12 p.

specifications

-- **Book of standards.** Current edition. About $15.

This book, updated periodically, gives national standards for treated wood products and the chemicals used to preserve them. Published by: American Wood-Preservers' Association (AWPA), Suite 444, 7735 Old Georgetown Rd., Bethesda, Md. 20014.

6 **Selection, production, procurement, and use of preservative treated wood: supplementing Federal specification TT-W-571.** 1977. By L. R. Gjovik and R. H. Baechler. Gen. Tech. Rep. FPL-15. 37 p. Free.

-- **Specifications and dimensions for wood poles—05.1-1972.** 1972. 20 p. About $2.

Published by: American National Standards Institute (ANSI), Inc., 1430 Broadway, New York, N.Y. 10018.

-- **Wood preservation: treating practices.** Latest revision. Federal specification TT-W-571. Free.

Single copies are free from Business Service Centers at regional offices of the U.S. General Services Administration.

service records of treated wood

6 **Comparison of wood preservatives in Mississippi post study.** 1977. By L. R. Gjovik and H. L. Davidson. Res. Note FPL-01. 16 p. Free.

6 **Comparison of wood preservatives in state tests.** 1977. By L. R. Gjovik and H. L. Davidson. Res. Note FPL-02. 79 p. Free.

-- **Post service records.** 1966. Report of Committee U-5 of the AWPA. Proc. Am. Wood-Preservers' Assoc. 62:60-130.

This publication lists agencies engaged in testing treated materials. It also includes the results of extensive tests of untreated and treated posts of many woods.

4 **Service life of treated and untreated fence posts—1976 progress report on the post farm.** 1977. By D. J. Miller and R. D. Graham. Res. Pap. 37. 18 p. Free.

buildings

6 **Bleaching wood.** 1967. 9 p. Free.

6 **Forest Products Laboratory natural finish.** 1972. By J. M. Black, D. F. Laughnan, and E. A. Mraz. FPL-046. 7 p. Free.

6 **List of publications on finishing.** 1978. 5 p. Free.

6 **Principles for protecting wood buildings from decay.** 1973. By T. C. Scheffer and A. F. Verral. 56 p. Free.

4 **Protect your home against decay and insects.** 1978. 26 p. Free.

4 **Useful information for the home owner and builder.** 1977. By R. D. Graham. 7 p. Free.

6 **Wood finishing: painting outside wood surfaces.** 1972. 4 p. Free.

appendix B
culturing fungi from wood t

Jonathan D. Lew [a]

Advanced decay in a wood pole can be visually detected in cores taken with an increment borer, and those same cores can be measured for shell depth and depth of preservative penetration. However, early decay—which is invisible—must be detected in the laboratory.

To detect invisible decay, place each core in a plastic straw which is stapled shut at the ends and labeled with line, pole number, core location, and other information. The cores should be brought to a laboratory and cultured within 24 hours—those that cannot be cultured within that period should be stored in a refrigerator.

Culturing, one of the most reliable methods for detecting early decay in wood, involves sterilizing the surface of the core, embedding it in sterile nutrient media, and incubating it 3 to 4 weeks at 21° to 27°C. Cores are observed weekly for fungal growth which is microscopically examined after 3 to 4 weeks for characteristics of a decay fungus.

[a]This procedure was written by Jonathan D. Lew while he was a research assistant with the Forest Research Laboratory, Oregon State University, Corvallis.

Equipment

- Small pair of forceps
- Alcohol (95% ethanol)
- Alcohol lamp or small Bunsen burner
- Scissors
- Culture dishes with nutrient media
- Wax pencil or felt tip marker
- Autoclave
- Balance accurate to 0.1 g
- Incubator or room at 21° to 27°C.

culturing area

The atmosphere contains spores of fungi and bacteria that can fall into the nutrient media during the culturing process, germinate, and contaminate the culture plate. To reduce contamination, keep the work area free of dust, drafts, and fungus-infested material. Before culturing, wipe down the work area with 95 percent ethanol or another suitable disinfectant. Work on a cloth dampened with disinfectant, or periodically clean the bench top with ethanol. If contamination problems persist, consider purchasing a tissue culture hood or a laminar flow, clean air bench. The tissue culture hood is a cabinet with an ultraviolet (UV) germicidal lamp that is switched on when the hood is **not** in use (UV radiation damages the eyes) to sterilize the cabinet interior. The laminar flow bench blows "sheets" of filtered air across the working surface in one direction to keep contaminating particles from falling into culture dishes.

nutrient media

Wood-rotting fungi are commonly cultured on an agar medium containing 2 percent malt extract.

To make the agar:

1. In a 2,000-ml Erlenmeyer flask, add 1,000 ml of distilled water, 15 g of agar, and 20 g of

malt extract. Malt extract is quite hydroscopic, so weigh and dispense it quickly. Swirl or stir until most of the malt extract is well suspended in solution. Cover the flask with aluminum foil, or plug it with a wad of cotton. Agar content can be varied to change the hardness of the media.

2. Place the flask in an autoclave for 20 minutes at 15 psi.

3. Turn off the autoclave, and allow it to cool slowly. Using an exhaust cycle before the chamber has reached atmospheric pressure will cause the medium to boil over.

4. Wipe off the working surface with 95 percent ethanol. Arrange 35 to 40 Petri dishes in stacks of 2 or 3 dishes each. Use either disposable dishes (presterilized polystyrene) or reusable glass dishes (autoclaved, washed, and oven-sterilized at 110°C for 8 hours).

5. Cool the medium to about 45° to 50°C. At this temperature, you should be able to touch the side of the culture flask to your face.

6. Pour the medium into the dishes. Pour from the flask, or transfer a portion of medium to a smaller sterile vessel (e.g., a 500-ml Erlenmeyer flask) before pouring. Cover the bottom of the Petri dish with a layer of medium 3 to 5 mm deep. Work quickly when pouring, and twirl the flask frequently to prevent the medium from solidifying. To reduce contamination when pouring, tip up one side of the Petri dish cover to expose as little of the medium as possible.

7. The malt agar should solidify and be ready for use in about 30 minutes.

enhancing recovery of decay fungi

Decay fungi frequently coexist with both nondecay fungi and bacteria. If you only want to detect early decay, you can eliminate these nondecay and bacterial organisms from your cultures by adding certain chemicals to malt agar. Such media (e.g., Russell 1956, Hunt and Cobb 1971) selectively inhibit the growth of nondecay fungi and bacteria without appreciably affecting the growth of decay fungi.

For controlling nondecay fungi, especially from Douglas-fir poles, we recommend a medium containing 10 parts per million (ppm) of Benlate.

Vigorously shake 20 mg of Benlate and 20 ml of sterile distilled water in a sterile screw-cap tube to form a suspension, not a solution. Add this mixture to 1,000 ml of malt agar. To control bacteria, add 3.0 ml of lactic acid per 1,000 ml of malt agar. Before adding either the Benlate mixture or the lactic acid, be sure the medium has cooled to about 50°C.

culturing fungi from increment cores

By now you have made up nutrient media dishes and wiped down your culture area—you are now ready to plate the cores. This can be done many ways, depending on personal preference. The important point in trying to culture fungi is to prevent contamination of the plate by airborne spores. Follow this general procedure to aseptically plate cores:

1. Work on a disinfectant-dampened cloth or a sterile paper towel. Wipe down the bench with 95 percent ethanol.

2. Label the dish cover with the information on the straw (line, pole number, location of core).

3. Snip off the end of the straw, and remove the core. If the core is badly broken due to decay or a dull increment borer, use the crease of a paper towel to keep the pieces oriented. If the core is not broken, break it into 2 or 3 segments that will fit into the Petri dish.

4. Sterilize the forceps by dipping them in alcohol and igniting them in the burner flame.

5. Flame the core segments to destroy superficial contaminants on the surface. Hold the core segment with sterile forceps, and pass it through the gas or alcohol flame for 2 to 3 seconds, momentarily exposing all surfaces directly to the flame. Scorching the core, other than a slight browning of edges, may kill the fungi in the wood.

6. While holding the flamed core with the forceps in one hand, use the other hand to tip up one side of the Petri dish cover just enough to place the core segment onto the agar surface. With the forceps, push down on the core segment to embed it in the agar. Close the dish at once.

7. Repeat steps 4, 5, and 6 until the entire core has been placed in the dish with as much distance as possible between segments. Whenever a dish is open, keep the cover over the exposed agar surface to prevent contamination.

8. Stack the dishes in a cardboard or plastic box with a closable top or in a temperature-controlled incubator at 21° to 27°C.

identification

Observe cultures once a week for 3 to 4 weeks. Note the presence, color, and texture of fungi growing from the core. In addition, be sure to note the presence of fungal or bacterial contaminants not growing directly from the core. On the underside of the dish, circle each contaminant with a wax pencil or felt-tip pen to insure their recognition later. If a culture becomes badly contaminated, you may have to transfer the uncontaminated portion of the core to another dish.

Cultures from infected wood frequently yield a mixture of decay and nondecay fungi. In many cases, these two groups can be separated on the basis of color, texture, and growth rate of the fungal mycelia. In culture, nondecay fungi generally are fast-growing and dark-colored, although the mycelia of many nondecay fungi are white initially and then darken. Decay fungi tend to grow rather slowly, and they have a white color and a downy, cottony, or felty texture. Using these criteria, the greenish fungus that covers the dish in a few days to a week fits into the nondecay group; the white, cottony fungus that becomes prominent after 2 to 3 weeks is probably decay. Although color, texture, and growth rate are helpful characteristics for differentiating between decay and nondecay fungi, sometimes positive identification requires a light microscope. Some nondecay fungi are white or off-white, whereas the white mycelia of some decay fungi are tinged with pink, yellow, or brown.

microscopic examination of cultures

You will be able to view the individual spores and hyphae of fungi with a microscope. The hyphae of most wood-rotting Basidiomycetes (general classification of wood rotters) possesses clamp connections—small, characteristically shaped bumps that arise as a result of cell division (Exhibit B-1). Only decay fungi have clamp connections, but sometimes they are rare or difficult to see. Nobles (1965) details the identification of decay fungi.

In addition to the absence of clamp connections, nondecay fungi are characterized by a wide variety of distinctively shaped spores, usually present in great numbers, and spore-bearing apparatuses. Barron (1972) and Barnett and Hunter (1972) have written keys to the *Fungi Imperfecti*, many of which inhabit wood as nondecay organisms.

A "squash mount" is the most common way to view fungi under the microscope. Place a drop of mounting media on a microscope slide; cut out a bit of the fungus with a dissecting needle; put it in the mounting media; and cover the fungus with a cover slip, being careful not to trap any air bubbles near the fungus. You can use a variety of solutions to make mounts, including water, glycerin, lactophenol, and 5 percent potassium hydroxide. Phloxine dye and 5 percent potassium hydroxide are commonly used for decay fungi. Lactophenol dyed with a little cotton blue may be helpful to view nondecay fungi.

With patience and practice, you should be able to distinguish decay fungi from nondecay fungi. However, positive identification of any fungi to the generic or specific level should be left to a mycologist.

You may find an agar-stick breaking-radius test a reasonably rapid means for differentiating between decay and nondecay fungi (Safo-Sampah and Graham 1976). Decayed sticks can be broken easily with one's fingers.

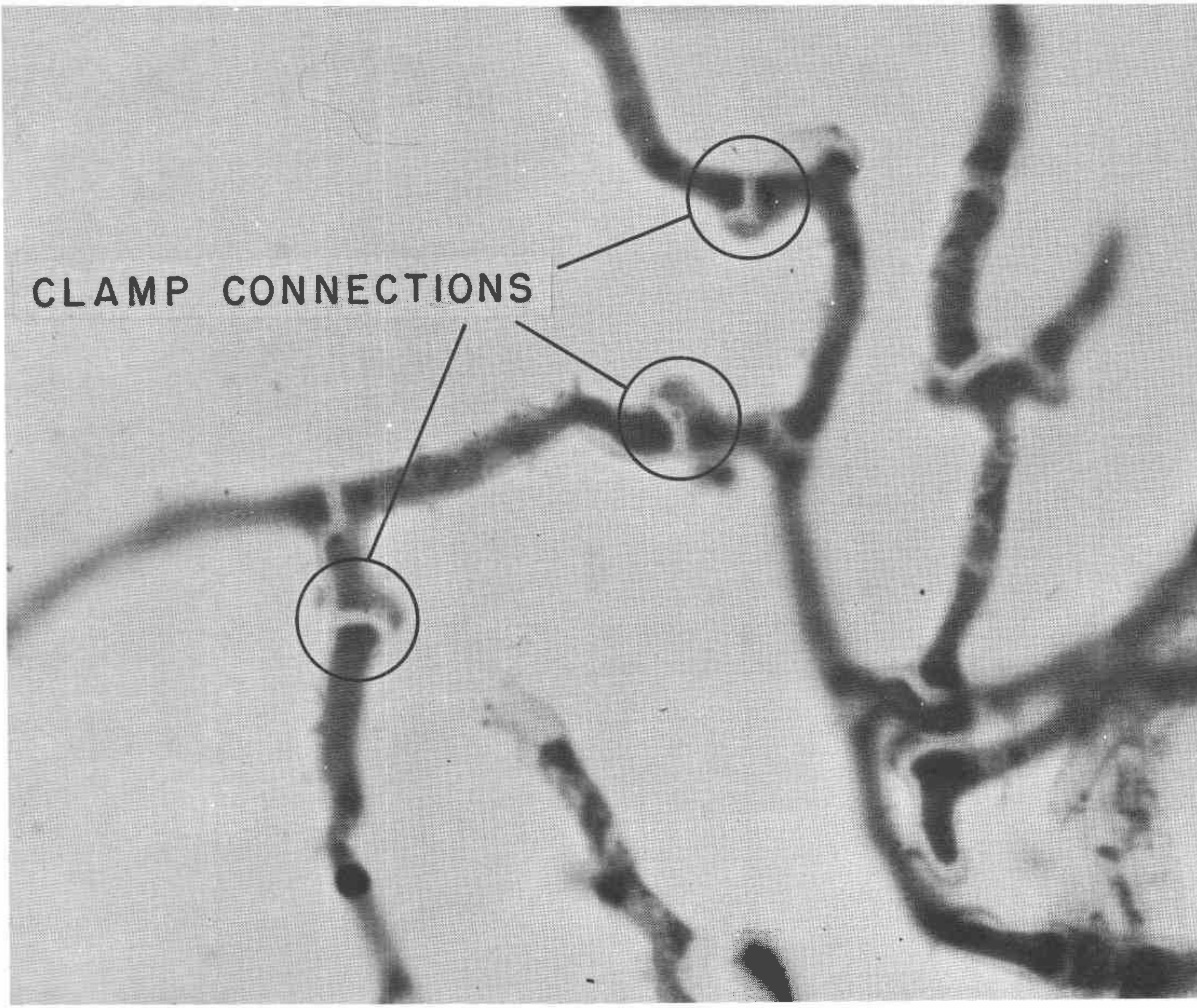

Exhibit B-1.

Hyphal strands of a decay fungus viewed under the microscope. Circles mark clamp connections characteristic of decay fungi.

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BARRON, G. L. 1972. The genera of hyphomycetes from soil. Robert E. Krieger Publishing Co., Huntington, N.Y. 364 p.

NOBLES, M. K. 1965. Identification of cultures of wood-inhabiting hymenomycetes. Can. J. Bot. 43:1097-1139.

SAFO-SAMPAH, S. and R. D. GRAHAM. 1976. Rapid agar-stick breaking-radius test to determine the ability of fungi to degrade wood. Wood Sci. 9:65-69.

British/Metric conversions

1 inch (in.)	= 2.54 centimeters (cm)
	= 25.40 millimeters (mm)
1 foot (ft)	= 0.30 meters (m)
	= 30.48 centimeters (cm)
1 cubic foot (ft^3)	= 0.028 cubic meters (m^3)
1 pound per square foot (psi)	= 6.89 kilopascals (kPa)
1 pound (lb)	= 453.592 grams (g)
32° Fahrenheit (F)	= 0° Celsius (C)
1 fluid ounce (oz)	= 29.57 milliliters (ml)
1 pint (pt)	= 0.473 liter (l)
1 ounce (oz)	= 28,350 milligrams (mg)

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WILCOX, W. W. 1964. Some methods used in studying microbiological deterioration of wood. U.S. For. Serv., Madison. Res. Note FPL-063. 24 p.

appendix C
sources of pole inspection equipment

These sources of equipment were reported by the utilities and inspection agencies that reviewed this manual. Inclusion here does not indicate endorsement by the authors or sponsoring agencies, nor does this list suggest that these are the only suppliers.

augers, bits

American Steel Co.
4033 N.W. Yeon Street
Portland, Oregon 97210

Irwin Bit Co.
Wilmington, Ohio 45177

Woodbury & Co.
P.O. Box 3154
Portland, Oregon 97208

drills, battery or electric

Black & Decker Manufacturing Co.
701 E. Joppa Road
Towson, Maryland 21204

electrical resistance pole testers

Delmhorst Instrument Co.
607 Cedar Street
Boonton, New Jersey 07005

Osmose Wood Preserving Co.
980 Ellicott Street
Buffalo, New York 14209

increment borers

Ben Meadows
3589 Broad Street
Atlanta (Chamblee), Georgia 30366

Forestry Suppliers, Inc.
Box 8397
Jackson, Mississippi 39204

Keuffel & Esser Co.
2701 Second Avenue
Seattle, Washington 98101

Keuffel & Esser Co.
Morristown, New Jersey 07960

sonic pole testers

Chapman Chemical Co.
P.O. Box 9158
Memphis, Tennessee 38109

Heath Energy Services, Inc.
33850 Armada Ridge Road
Richmond, Michigan 48062

x-ray pole testers

Heath Energy Services, Inc.
33850 Armada Ridge Road
Richmond, Michigan 48062

appendix D
computer-aided wood pole maint

Winston S. Acton[a]

Utilities first used computers for fiscal and inventory control because the computers could store, recover, process, and print out millions of pieces of information with fantastic speed. Later, with the advent of increased capabilities and easier programming, computers were applied to engineering problems, then to the operations field. Now computers are connected "on line" to control, with minimal human intervention, the flow of electricity in utility power systems.

However, computer application to pole maintenance has lagged, probably because maintenance managers are seldom computer-oriented and because computer programmers seldom understand maintenance problems. Consequently, this paper outlines some general principles for computerizing a pole maintenance program, and it describes one successful application.

computer programs

Managers, supervisors, and linemen involved in maintenance of poles can do their jobs more easily and more efficiently if each has ready access to information about the physical plant and to lists of work to be done. Computers very proficiently compile such lists including descriptions of poles and other facilities in service, work needed, personnel available, work completed, costs, and related information. Instead of being stored in written reports, such basic information can be coded and stored on files (data bases) within a computer system. Computer programs are used to create and maintain these files and to gain access to information in them. When requested in writing by the user, the computer sorts, selects, processes, and prints the required lists of information. An organized arrangement of stored data, computer programs, and written user instructions is known as a "system."

A system can be large, powerful, and multipurpose, or it can be small, involving a number of limited systems. Large systems more efficiently use computer resources and ordinarily require less effort to operate. However, independent, compatible, small systems can more easily be modified to accommodate inevitable changes. Furthermore, individual small systems can be developed and made operational in priority order, gaining both rapid returns from the developmental effort and less expensive operating experience.

The small systems should be as compatible and as interchangeable as possible—that is, one computer program should be able to access several data bases, and one data base should be accessed by several programs. Operation of the different systems should be as similar as possible to make learning easier for the users and to simplify writing user instructions, frequently the major task in system development.

Sometimes systems are established by merely copying existing handwritten maintenance records, perhaps using "canned" computer programs to create and maintain a data base and to print reports from it. This eliminates manual record-keeping and produces lists. However, to maximize use of a computer's power and versatility, a data base must be designed for the computer.

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Information (items) for computer processing should be expressed in a concise, systematic manner, readily interpretable by both people and computers. Actual measurements or other numeric values, where appropriate, are ideal. For example, voltage rating is best expressed directly in volts or kilovolts, not a mixture of both! Year values can be two-digit numbers. Where actual numeric values are not appropriate, alphabetic, numeric, or alphanumeric codes or abbreviations work well. A good example is the set of two-letter state abbreviations adopted by the U.S. Post Office. The number of characters representing the value of a given data item should always be the same; the number needed depends on the range of values expected. For example, wood pole species probably will not exceed a dozen different values, so can be represented by a single letter. Codes should be assigned as meaningfully as possible for easy memorization and interpretation.

In designing a data base, you may be tempted to include items that might be wanted in the future. Incorporating such items with no definite purpose is usually a mistake. Changes are bound to occur, so the design of the data base needs flexibility to accommodate changes.

Simple operating and printout formats with easily understood data codes require serious attention because they largely determine user acceptance of a system.

the wood pole history system

The computerized "Wood Pole History System" used by the Bonneville Power Administration (BPA) handles management information for wood pole maintenance. It is one of a family of essentially identical systems such as "Brush Control Records" and "Insulator and Hardware Data" covering various activities for maintaining the transmission lines. These systems utilize the same user procedures to alter, delete, or insert information in the various data bases and to print data base contents. Each data base is built up of 80-character records, a size chosen for compatability with standard punched cards. Each record contains identification coding followed by either formal (coded) data or informal (narrative) comments. A group of records contains the information for one management unit. An individual pole is the management unit for the Wood Pole History System.

identification

The pole identification scheme is the key for locating records in a data base, information in a printed report, and the management unit itself (pole) in the field. For example, vehicles can be identified by license plate number, and persons can be identified by name (poor) or by Social Security number (good) for computer processing. Each electric utility company has its own scheme for identifying poles in service.

BPA is divided geographically into areas which, in turn, are divided into districts—a district is that part of the physical plant assigned to one maintenance crew. Transmission lines are divided into miles which are divided into structures having one or more poles. A pole can be completely identified by combining codes for area, district, mile, structure, and pole. Areas, districts, and transmission lines are named; miles and structures within miles are numbered; and poles within structures have a letter. The full written identification is much too unwieldy for computer processing. Because alphabetic abbreviations for the named elements proved unsatisfactory, a one-digit number was assigned to represent each area name, another one-digit number to represent the district within the area, and a two-digit number to represent the transmission line within the district. The resulting four-digit codes were called "ADNO" numbers. Incidently, that acronym soon grew into a common nickname for the Wood Pole History System.

To avoid substitution of dull, anonymous numbers for familiar, meaningful names, a small, auxiliary data base contains the ADNO numbers and their associated area, district, and line names. This enables report-printing computer programs to translate ADNO numbers into full names which are shown as page headings or footings. The ADNO numbers have to be written on field reports (Exhibit D-1) for input to the system. We feared this would lead to errors—it hasn't.

Pole identification in the system data base is a ten-character code consisting of a four-digit ADNO number, a three-digit mile number, a two-digit structure number, and a one-letter suffix, in that order written together like this: 724100508C. The letter suffix indicates the position of a pole within a structure. User procedures include the ability to change identification without changing the data and to sort records within a data base by identification code.

formal data

"Formal data" include that part of the data base information (besides the identification) to be processed by the computer. It must be written—usually in code—and entered into the data base strictly according to the rules established for the system involved. For wood poles, the formal data can be divided into basic data, test results, treatments applied, and "other."

The basic data are that information which does not change during the life of the pole such as length, circumference, class, species, original treatment, year manufactured, manufacturer, year installed, and possibly other items. Basic data in the Wood Pole History System are limited to just three items: a three-digit number for length in feet, a one-letter code for "kind" which combines species and original treatment, and a two-digit number for the year manufactured. Other items were considered for inclusion, but either the information was unavailable or unnecessary. For example, because all poles in the plant are class 2, these data were not recorded.

Wood pole inspection tests can range from casual visual once-overs through simple measurements to precision procedures with sophisticated instruments. The Wood Pole History System currently provides for three measurements plus six visual appraisals. At one stage of development, the system could store past inspection results, but this became so complicated that the feature was dropped. Now each new inspection test overwrites the old so past inspection results are lost. The data might be useful for research but, from a management standpoint, only the latest information is of interest.

Heart rot is the dominant pole destroyer in this region. The extent of groundline heart rot (GLHR), aboveground heart rot (AGHR), and pole-top heart rot (PTHR) is recorded (Exhibit D-2). Tests for GLHR and AGHR are made by drilling and recording results at up to four quarters around the circumference of the pole. One digit is used for each quarter: "9" indicates a sound quarter regardless of actual pole radius; "8" indicates a small heart rot pocket; lesser numbers indicate inches of sound wood; and "0" indicates an exposed cavity. For AGHR, an additional two-digit number shows its height above ground in feet. Tests for PTHR are made by probing downward from the pole top and are recorded as a one-digit number for approximate heart rot diameter and a two-digit number for length, both in inches. Recording sound wood for GLHR and AGHR and rotten wood for PTHR seems inconsistent, but it suits the inspection methods without confusion. The year tested is recorded in all three cases.

The six visual appraisals include shell rot, cracks or checks, insect damage, bird damage, fire damage, and other damage. The first letters of these miscellaneous tests spell "SCIBFO," another popular acronym. In each case, test results are recorded by a single letter: "G" for good, no problem; "F" for fair, some deterioration or damage but still serviceable; and "B" for bad, schedule for replacement. The tests are undated, but all lines are patrolled annually and the patrolmen are expected to update the SCIBFO inspection results if they find field conditions at variance with recorded information.

Many treatments, some developed by individual utilities and some sold commercially, are intended to prolong pole life. At one time the Wood Pole History System had columns allotted to five different treatments, but one proved ineffective and another was applied so infrequently as not to warrant space in the formal data. The remaining three are groundline heart rot treatment (Vapam), aboveground surface treatment (spray), and pole-top preservative treatment (grease). Each treatment is recorded as a two-digit number showing the year applied.

The "other" formal data are information not actually about the pole itself, but important to wood pole maintenance. The Wood Pole History System includes a four-character code each for structure design and type, a two-digit number for the year the crossarm was installed, a one-character code each for crossarm inspection results and for test method, and a two-digit number for the year the crossarm was inspected. Because the information applies to the structure as a whole, it is recorded with the 'A' pole only on H-frame structures to avoid duplication.

Formal data are allotted one 80-character record per pole in the data base. The first 10 characters contain the identification, and the last 2 are reserved for control purposes—hence 68 are available for data. The formal data described previously occupy 51 characters, leaving 17 for future expansion. To improve readability when printed, the data are interspersed with blank spaces so 51 characters of data occupy 76 characters of printline.

informal comments

Informal comments are not intended for processing by computer, but they are a valuable source of information. Written as English words, common abbreviations, or familiar code, they are printed exactly as written.

Comments are used to record pole or structure information not allotted space in the formal data. The Wood Pole History System includes structure accessories such as guys and braces, drawing reference for special structures, and foreign contacts and underbuilds. Comments are often used to elaborate information in the formal data—for example, to explain the reason for a "B" in a SCIBFO column. The formal data can record only one AGHR test, but several may be made at different heights on the same pole; in such cases, the worst test result is put in the formal data where the computer can read it, and the others are noted in comments. As pointed out before, previous test results are lost when new test results are entered into the formal data. An old test having special interest can be transcribed to the comments and saved.

Field crews are encouraged to use comments freely to record information of interest to them, and they do. Many comments about access problems, hot crossings and other hazards, and work needed on a structure appear in the printouts. The system permits up to nine informal comments per pole. Each record prints out one line of comments. Although a record can store 68 characters of information, available space in the print line limits the length of the comment line to 45 characters. Nine 45-character lines make a respectable piece of prose. So far, no pole has needed all the spaces in the data base.

system operation

The master file of Wood Pole History records is kept on magnetic tape. User procedures provide means to insert new records into the file and to delete existing ones. Information in existing records, both formal data and informal comments, can be altered to keep the file up to date. When a pole is replaced, the formal data for the old pole can be automatically transferred to a "dead file" and saved for research and analysis.

Most of the updating is from the "Wood Pole Inspection and Maintenance Report" (Exhibit D-1) sent in by field crews. The reports are audited and keypunched along with any additional updating information prepared in the central office. Then the punched cards and the master file are run through the computer under control of the primary Wood Pole History computer program. An updated master file results.

The same computer program can print the contents of the master file in book form. When printed, the file is automatically divided by districts; that is, a separate book is produced for each maintenance district listing only the poles in that district. Usually multiple copies are made because the books are popular with field crews and are carried in their work vehicles. Each Wood Pole History book (Exhibit D-3) has a title page, legend and other fixed information, an "ADNO List" showing ADNO numbers and associated names, and the individual pole data. The Preface and ADNO List are kept as small files of punched cards. To print the books, the computer must have access to these as well as to the master file. A book for 5,000 poles contains about 250 pages and is 1-inch thick.

Separate, auxiliary computer programs access the master file and select poles meeting specified criteria such as lists of poles to be inspected, to be treated, or to be replaced. Other auxiliary programs print out summary tabulations showing pole counts by age, kind, length, and other characteristics. The possibilities are limited only by the available formal data in the master file and the ingenuity of the programmer.

ADNO

1	2	3	4

WOOD POLE INSPECTION AND MAINTENANCE REPORT

Line Name ______________________ Inspector ______________________

IDENT.			BUTT INSP.		AGHR INSP.			CLIMB			MISC.						TREATMENTS		
MILE	STR	P	POLE QTRS 1 2 3 4	YR INS	HT	POLE QTRS 1 2 3 4	YR INS	HRT ROT DIA	HRT ROT DPTH	YR INS	SHELL ROT	CRACKS	INSECT	B/A	FIRE	OTHER	VAPAM	ABOVE GROUND	POLE TOP
5 6 7	8 9	10	25 26 27 28	29 30	31 32	33 34 35 36	37 38	39	40 41	42 43	44	45	46	47	48	49	50 51	52 53	54

COMMENTS (COMPUTER PROCESSABLE)

MILE	STR	P	COMMENT
5 6 7	8 9	10	11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 4

POLE REPLACEMENT: OLD POLE

E	O
79	80

MILE	STR	P	WORK ORDER	P/E	CAUSE	INS	X ARM	DATE MO	DATE DAY	DATE YR
5 6 7	8 9	10	11 12 13 14 15 16	17	18 19 20	21 22	23	24 25	26 27	28 29

POLE REPLACEMENT

MILE	STR	P	DESIGN	TYPE
5 6 7	8 9	10	11 12 13 14	15 16 17

INTERIOR – BONNEVILLE POWER ADMINISTRATION, PORTLAND, OREGON

Exhibit D-1.

Field report forms used by the Bonneville Power Administration.

A	O
79	80

Date ____________

X-ARM															
YR RPLD		COND	METHOD	YR INS											
6	57	58	59	60	61	62	63	64	65	66	67	68	69	70	

													A	9
													A	9
													A	9
													A	9
2	43	44	45	46	47	48	49	50	51	52	53	54	79	80

EW POLE

I	O
79	80

LENGTH			K	YR INST		TREATMENTS VA		TREATMENTS PT		X-ARM YR RPLD		X-ARM C	X-ARM M	YR INSP	
19	20	21	22	23	24	50	51	54	55	56	57	58	59	60	61

BPA 1007 Rev. June 1973

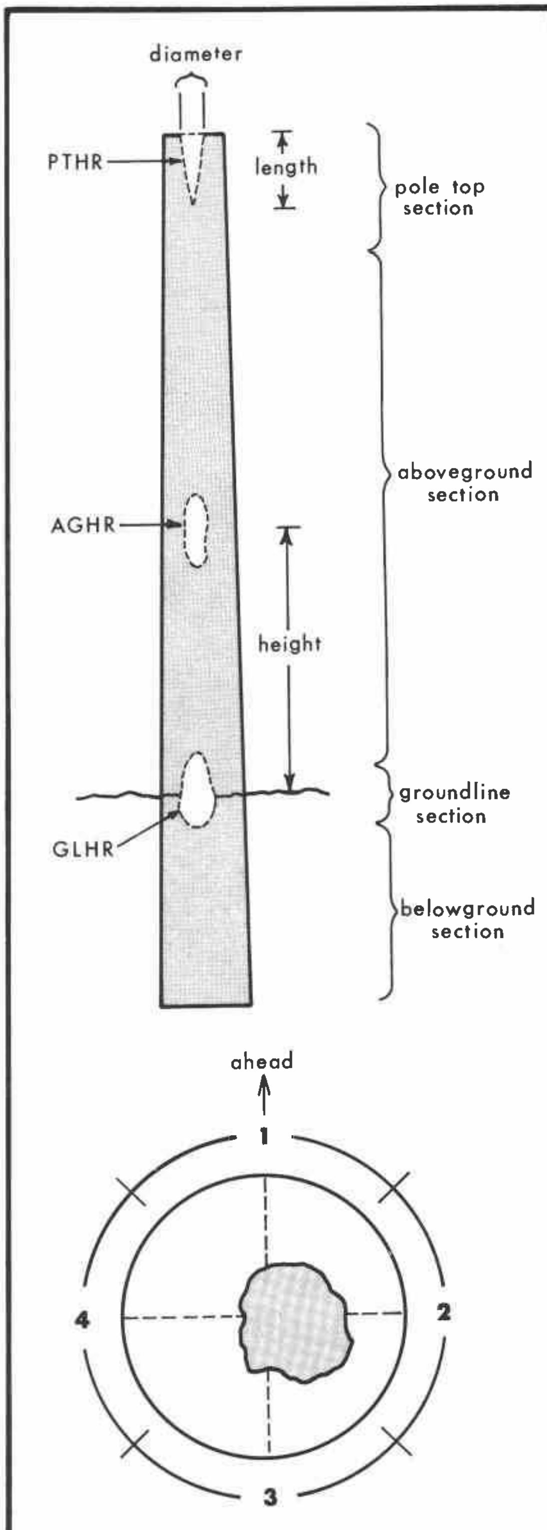

Exhibit D-2.

Location and coding of tests made with a drill during field inspection of poles.

Exhibit D-3.

This Wood Pole History book, prepared by computer for field use, may have 250 pages.

Exhibit D-3

Title page.

```
#   #  ###   ###  ####      ####   ###  #     #####
#   # #   # #   # #   #     #   # #   # #     #
# # # #   # #   # #   #     ####  #   # #     ###
## ## #   # #   # #   #     #     #   # #     #
#   #  ###   ###  ####      #      ###  ##### #####

#   # ###  ###  #####  ###  ####  #   #
#   #  #  #       #   #   # #   #  # #
#####  #   ##     #   #   # ####    #
#   #  #     #    #   #   # #  #    #
#   # ### ###     #    ###  #   #   #
```

THIS "WOOD POLE HISTORY" CONSOLIDATES WOOD POLE RECORDS IN READILY ACCESSABLE, EASILY REPRODUCED, MACHINE PROCESSABLE BOOKS AND FILES. THE HISTORY IS UPDATED VIA FORM BPA 1007 WHICH IS USED FOR FIELD REPORTS OF WOOD POLE MAINTENANCE AND REPLACEMENTS. CARE AND ACCURACY IN USE OF THE FORM IS VITALLY IMPORTANT.

DETAILS ABOUT USE OF THE FORM AND WOOD POLE MAINTENANCE IN GENERAL ARE FOUND ON THE BACK OF THE BPA 1007 FORM, IN THE PORTLAND AREA "WOOD POLE AND CROSSARM MAINTENANCE GUIDE", AND IN THE BRANCH OF MAINTENANCE "WOOD POLE MAINTENANCE STANDARD". THESE PREFACE PAGES GIVE INFORMATION HELPFUL IN USE OF THIS BOOK.

THE PRINTED DATA LINES ARE DOUBLE-SPACED FOR LEGIBILITY AND TO PROVIDE SPACE FOR HANDWRITTEN NOTES. USERS ARE ENCOURAGED TO RECORD INFORMATION IN THIS MANNER FREELY. NOTATIONS OF GENERAL AND RELATIVELY PERMANENT INTEREST CAN BE MACHINE-PRINTED UNDER "COMMENTS".

THIS BOOK IS ONLY AS GOOD AS THE DATA IT CONTAINS. PLEASE WATCH FOR AND CORRECT OR REPORT ANY EXISTING ERRORS FOUND, AND BE CAREFUL NOT TO INTRODUCE NEW ONES ON FIELD REPORTS.

Exhibit D-3.

Legend.

IDEN	IDENTIFICATION OF POLE
MIL	MILE NUMBER
SR	STRUCTURE NUMBER
P	POLE LETTER ("S" = STEEL OR OTHER NON-WOOD STR)

Exhibit D-3.

Legend (continued).

```
STR     STRUCTURE DATA

  DSGN  DESIGN SERIES (SEE "DESIGN SERIES CODES")

  TYPE  TYPE (SEE "STRUCTURE STANDARD DRAWINGS")


POLE    POLE DATA

  LNH   LENGTH IN FEET

  K     KIND, CODED AS FOLLOWS:

        C  CEDAR, BUTT TREATED
        D  FIR, DRILLED AND FULL-LENGTH TREATED
        E  FIR, "CELLON" TREATED
        F  FIR, FULL-LENGTH TREATED, NOT DRILLED
        L  LARCH OR TAMARACK, FULL-LENGTH TREATED
        P  CEDAR, FULL-LENGTH TREATED
        X  OTHER KINDS, SPECIFY IN "COMMENTS"

  YR    YEAR MANUFACTURED (POLE STAMP DATE)


GLHR    GROUND LINE HEART ROT TEST

  1234  TEST RESULTS, INCHES OF GOOD WOOD BY POLE QUARTERS
        ("G" IN QTR 1 = GOOD SONIC TEST)

  YT    YEAR TESTED

AGHR    ABOVE GROUND HEART ROT TEST

  HT    HEIGHT ABOVE GROUND IN FEET ("99" = TESTED FULL LENGTH)

  1234  TEST RESULTS, INCHES OF GOOD WOOD BY POLE QUARTERS
        ("G" IN QTR 1 = GOOD SONIC TEST)

  YT    YEAR TESTED

PTHR    POLE TOP HEART ROT TEST

  D     DIAMETER OF ROT POCKET IN INCHES

  LN    LENGTH OF ROT POCKET IN INCHES

  YT    YEAR TESTED
```

Exhibit D-3.

Legend (continued).

MISC	MISCELLANEOUS TESTS, ALL CODED AS FOLLOWS:
	G GOOD, NORMAL, NO PROBLEM F FAIR, SOME DAMAGE OR DETERIORATION B BAD, SCHEDULE FOR REPLACEMENT BLANK OR PERIOD = NOT REPORTED
S	SHELL ROT CONDITION
C	CRACKS, CHECKS, OR BREAKS CONDITION
I	INSECT DAMAGE
B	BIRD OR ANIMAL DAMAGE
F	FIRE DAMAGE
O	OTHER, SPECIFY IN "COMMENTS"
TMTS	TREATMENTS, YEAR APPLIED
GL	GROUND LINE (VAPAM)
AG	ABOVE GROUND (SPRAY)
PT	POLE TOP (GREASE)
XARM	CROSSARM DATA
YR	YEAR INSTALLED
C	CONDITION ("G,F,B" OR INCHES OF GOOD WOOD)
M	METHOD OF TEST, CODED AS FOLLOWS:
	D DRILL H HAMMER S SONIC C CLOSE, CLIMBING V VISUAL, FROM GROUND A HELICOPTER
YT	YEAR TESTED

Exhibit D-3.

Legend (continued).

```
COMMENTS  SOME COMMONLY USED ABBREVIATIONS:

          AG  ABOVE GROUND          FG  FIBER GLASS
          AH  AHEAD ON LINE         GW  GOOD WOOD
          BG  BELOW GROUND          HR  HEART ROT
          BK  BACK ON LINE          SR  SHELL ROT
          CI  CLIMBING INSP.        WP  WORKING PATROL


COMMENTS  STRUCTURE ACCESSORIES CODED AS FOLLOWS:

           BNT  BAYONET
           GBR  GROUND BRACE (DWG 63129)

           GGA  OHG GUY AHEAD
           GGB  OHG GUY BACK
           GGL  OHG GUY LEFT
           GGR  OHG GUY RIGHT
           GGS  OHG GUYS AHEAD AND BACK

           GSG  GROUND SLUG (DWG 147541)

           HXL  HX GUY LEFT
           HXR  HX GUY RIGHT
           HXS  HX GUYS LEFT AND RIGHT


           LGA  LINE GUY AHEAD
           LGB  LINE GUY BACK
           LGS  LINE GUYS AHEAD AND BACK

           OHG  OVERHEAD GROUND WIRE
           PTR  POLE TOP REPAIR BRACKET (DWG 128165)
           SBR  SWAMP BRACE (DWG 33827)

           SGL  SIDE GUY LEFT
           SGR  SIDE GUY RIGHT
           SGS  SIDE GUYS LEFT AND RIGHT

           SJC  SECTIONALIZING JUMPER COUPLINGS
           UBD  UNDERBUILD
           XBR  X-BRACE
```

Exhibit D-3.

Identification of pole lines.

```
           ADNO                LINE NAME

           1101  ZERO - ONE
           1112  ONE - TWO
           1123  TWO - THREE
           1134  THREE - FOUR
```

Exhibit D-3.

Data for individual poles.

--IDEN-- MIL SR P	---STR--- DSGN TYPE	--POLE-- LNH K YR	-GLHR-- 1234 YT	---AGHR--- HT 1234 YT	-FTHR- DLN YT	-MISC- SCIBFO	--TPTS-- AG PT GL	--XARM-- YR CM YT	COMMENTS 02/22/73 PAGE 1
1 1 A	32SX F	80 C 53	9 9 68		000 71	FFGGGG	65 71	53 BD 71	OHG,GGS XARM HAS 3" GW AT B POLE, DRILLED GOOD AT A & C POLES
1 1 B		75 C 53	9 9 68	58 99 71	208 71	FFGFGG	65 71		3 SMALL WDPKR HOLES 58' AG
1 1 C		80 C 53	5657 72		000 71	FFGGGG	65 71 72		OHG,GGS
1 2 A	32HF A1	70 F 53	9 9 63		320 71	GGGGGG	71	72	OHG
1 2 B		65 P 64			000 71	. .	71		OHG
1 3 A	32SX A2	80 C 53	9 9 68		000 71	FFGGFG	65 71	53 GD 71	OHG,X3R SCORCHED TO 20' AG 1960
1 3 B		80 F 53	G 71	15 98 71	212 71	GFFGFG	71	53 BD 71	OHG CHARRED NEAR GL BY GRASS FIRE 1960 FEW BUP HOLES 15' UP XARM HAS 3" GW AT A POLE, 2" GW AT B POLE, BUPS END TO END
1 4 A	32SF D	60 F 53	4366 71	06 3457 71	424 71	GFBGGG	71 71	53 GH 71	END OHG,GGA REPLACE SOON /1007 12-13-71
1 4 B		60 F 53	G 71		000 71	GFGGGB	71	53 GH 71	END OHG,GGA SMALL POLE, BADLY WOWED, SHOULD REPLACE /1007 12-13-71
1 5 A	31WB E	85 C 53	9 9 68		000 68	FG G.			
1 5 G		35 F 60	9 9 70	99 G 71	000 71	GFGGGF	71		2"X5"X4' SLAB SPLIT OFF BY VEHICLE 1965, EXPOSED WOOD PENTA TREATED
1 6 A	31WB A1	75 C 53	9 9 68		000 68	FGGG.	68	53 GW 68	2" SR /WP 11-13-68
1 7 S									BEGIN CONCRETE POLES

LINE TOTAL 12 POLES

WOOD POLE HISTORY TEST AREA FIRST DIST 1101 ZERO - ONE

checklist for pole inspection and treatment

1 READ THE MANUAL

aboveground inspection

2 **LOOK** for damage to poles and attachments, holes by woodpeckers, and insects, surface rot, sawdust, and mud tunnels.
3 **SOUND** with hammer for shell rot or internal rot.
4 **CORE** suspicious areas. Measure shell depth and depth of preservative around pole.
5 **CORE** near the widest check at groundline. Measure shell depth and depth of preservative around pole.
6 **REJECT BAD POLES–REPORT DANGEROUS POLES!!!**

belowground inspection

7 **PROBE** for surface rot, **CORE** for internal rot.
8 **FLOOD** and **PLUG** all inspection holes.
9 **SHAVE OFF** surface rot, **MEASURE** the pole's circumference.
10 **REJECT BAD POLES–REPORT DANGEROUS POLES!!!**

treating

11 **SURFACE TREAT** shaved poles or all poles.
12 **INTERNAL TREAT**
13 **DRILL** holes in a spiral pattern downward toward the center—avoid checks.
14 **PLACE** the chemical in the bottom hole first. Wear protective clothing and glasses.
15 **PLUG** holes. Wear protective clothing and glasses.
16 **BACKFILL** and **TAMP**

!!! caution !!!

CHEMICALS ARE TOXIC TO MAN

READ AND UNDERSTAND THE LABEL

KNOW EMERGENCY PROCEDURES

HAVE LABEL AND SAFETY MATERIALS AVAILABLE

Hospital ______________________ ______________________

Phone ______________ ______________

Poison Control Center ______________________ ______________________

Phone ______________ ______________

Graham, Robert D. and Guy G. Helsing. 1979. **Wood pole maintenance manual: inspection and supplemental treatment of Douglas-fir and western redcedar poles.** Forest Research Laboratory, Oregon State University, Corvallis. Research Bulletin 24. 64 p.

The success of a pole maintenance program rests squarely on the decisions made by the pole inspector and the manager of the wood pole system. As a basis for informed decisions that will increase both the safety and service life of poles, this manual provides basic information about wood, attacking organisms, inspection equipment, and supplemental treatments. Appendices cite pertinent publications, detail laboratory procedures for culturing fungi from poles, list sources of equipment, and tell how to develop a computerized record-keeping system for poles. This manual is intended as both a learning tool and a reference source.

Graham, Robert D. and Guy G. Helsing. 1979. **Wood pole maintenance manual: inspection and supplemental treatment of Douglas-fir and western redcedar poles.** Forest Research Laboratory, Oregon State University, Corvallis. Research Bulletin 24. 64 p.

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key word test

This manual should help you understand the meaning and significance of these key words. Test yourself, and refer to the manual for those that are unfamiliar to you.

Pacific Coast Douglas-fir
interior Douglas-fir
western redcedar
durability
permeability
density
moisture content
seasoning checks
widest check
sapwood depth
heartwood
cellulose
lignin
ring shake

preservative treatment

creosote
pentachlorophenol
waterborne preservatives
preservative penetration
preservative retention
assay zone
incised poles
through-bored poles
kerfed poles
pole specifications

wood destroying organisms

decay fungi
brown rot
white rot
soft rot
nondecay fungi
fruit bodies
fungal spores
fungal hyphae
Buprestid beetles
drywood termites
dampwood termites
subterranean termites
carpenter ants
woodpeckers
marine borers
shipworms
Limnoria

[illegible]ay patterns

sound wood
decay
incipient decay
solid wood
rot
surface rot
shell rot
internal rot
rot pockets
shell thickness
climate index map

inspecting poles in service

scraping devices
hammer
brace and bit
power auger
increment borer
Pol-tek
Shigometer
moisture meter
shell thickness indicator
nutrient media
bioassay
chemical analyses
pick test

treating poles in service

groundline treating
bandage treatments
surface treatments
internal treatments
fumigant
Vapam
chloropicrin
Certified Pesticide Ap[illegible]tor

organization

U.S. Environmental Pr[illegible]ion Agency
American Wood-Preservers' Association
American National Standards Institute

forest research laboratory
school of forestry
oregon state university
corvallis, oregon 97331