WOOD POLE PURCHASING, INSPECTION, AND MAINTENANCE: A SURVEY OF UTILITY PRACTICES

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ABSTRACT

Deregulation and consolidations have changed the operating environment for electric utilities in the United States. One important aspect of this change that may be overlooked is how utilities manage one of their most important assets: the wood poles that support their electric transmission and distribution system. The purchasing, inspection, and maintenance practices related to wood use by 261 North American utilities were surveyed. The results were compared with a similar, but less intensive survey performed in 1983. The survey showed that most utility practices were unchanged from those found in 1983, but that many utilities were exploring alternative pole materials. Utilities also appeared to have some misconceptions concerning pole service life, a factor that could influence the selection of alternative materials. The survey also showed that those charged with specifying and maintaining wood poles come to their jobs with little formal training in wood as a material. These results suggest the need for more continuing education offerings to better educate utilities concerning how to best manage their wood pole systems for maximum value.

Wood poles have a long history of providing excellent service for supporting overhead electrical and telecommunication lines. These lines represent up to 40 percent of the net value of some utilities. More importantly, failures of these lines can interrupt service, reducing sales and resulting in costly emergency repairs.

In recognition of these risks, the National Electric Safety Code (NCSC) requires that utilities regularly inspect and maintain the poles in their systems and that they replace structures in which strength has declined below 66 percent of the original design value. Most utilities meet NCSC requirements through regular inspection and remedial treatment programs that have evolved to address individual utility needs.

A 1983 survey showed that most utilities had some type of inspection program, although the frequency of inspections, the procedures employed, and the treatments applied to arrest decay varied widely (Goodell and Graham 1983). This survey was performed in an era when utilities were more tightly regulated. Recent moves to deregulate utilities, coupled with substantial downsizing and a trend toward consolidation, have sharply altered the utility operating environment. Despite these major changes, utilities must still reliably deliver power to their customers using overhead lines that are primarily supported by wood poles. Thus, the conflict between the need to be more profitable, while maintaining reliability, may cause utilities to alter their inspection programs. In order to explore that potential, the following study was performed.

The objectives of this survey were to assess 1) material preferences for utility poles; 2) inspection practices; 3) remedial treatment practices; and 4) perceptions concerning remedial treatment efficacy and safety.

MATERIALS AND METHODS

A questionnaire was developed for this study based upon previous work by Goodell and Graham (1983). A number of additions were made in order to gain additional insights concerning material preferences, remedial treatment perceptions, and inspection practices. The survey sought information on location,

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type, and ownership of the utility; characteristics of wood poles in the system (number, wood species, and initial preservative treatment); the number of wood poles purchased in 1997; whether the respondent used any treatment-enhancing processes for Douglas-fir poles (such as through boring or radial drilling); whether the utility inspected new poles; and what service life expectations they had for a given species. We also surveyed maintenance practices to determine whether utilities contracted inspection, and if so, whether they audited the contractor. We then inquired about the inspection frequency for each wood pole species and what tools were used. Utilities were asked about levels of carpenter ant and woodpecker attack in their systems and what treatments they currently used; they were then asked to assess each treatment on the basis of performance and safety. Utilities were also asked whether they had used wood substitutes in the past 5 years. Finally, the respondents were asked to provide their original field of trading.

The survey was pretested on five utilities (one public, four investor-owned) located in five different states. The questionnaire was then modified based upon feedback from these respondents.

The survey was initially mailed to 1,100 utility engineers, purchasing agents, and specifiers across the United States. This mailing was followed by a reminder postcard 2 weeks later. The population of interest consisted of rural electric cooperatives, public utilities, municipal utilities, and investor-owned utilities located across the United States (including Alaska and Hawaii). The initial mailing and reminder postcard resulted in 173 usable surveys, while another 70 surveys were undeliverable. A subsequent mailing 6 months later to non-respondents produced an additional 88 responses (25.2% total response rate).

The results were tabulated on an overall basis for all questions except the pole material preferences question. In this case, the results were tabulated on the basis of utility ownership (investor or public), region of the country, and number of poles in the system to determine whether these characteristics affected their pole purchasing practices.

Non-response bias was assessed by comparing 27 respondents to the initial survey with 27 respondents to the second mailing from the same states and from similar-sized utilities. The responses from these utilities concerning pole material preferences and for the questions concerning incidence of carpenter ants and woodpeckers were compared using Tukey's Studentized Range Test to see whether there were significant differences between the two groups (SAS 1999).

RESULTS AND DISCUSSION

Two hundred sixty-one responses were received from the two mailings. Often, however, the respondents lacked information to respond to one or more questions. Wherever possible, a follow-up telephone call was made to try to collect that missing information, but this was only possible when the respondent was identified. Non-response bias tests showed that there was no significant difference between early and late responses concerning pole material preferences, carpenter ant attack levels, woodpecker attack levels, or amount spent each year for woodpecker repairs ($\alpha = 0.05$).

UTILITY SIZES

The majority of respondents maintained 10,000 to 50,000 poles within their system. This level partially reflected the large number of public utilities among the respondents. Wood poles tended to be an important component of most utility systems. Although 82 of 261 respondents (31%) limited wood pole usage to lines with voltages below 70 kV, 72 used wood up to 230 kV (28%) and an additional 65 (25%) employed wood for lines above this level. No utility reported using wood poles to support lines above 345 kV, which is typically considered the upper limit for wood usage.

Most respondents would be broadly classified as public utilities, reflecting the large number of rural utility systems located across the United States. Public utilities represented 120 of the 259 respondents (46%), followed by cooperatives (58 respondents or 22%), investor-owned (57 responses or 22%), and government (5 responses or 2%). Most of the responding utilities were located in regions where the risk of decay was somewhat low. Fully 116 of 261 respondents to this question (44.4%) had some or all of their service territory in Zones 1 or 2 (where Zone 1 represents low rainfall/cooler temperatures and 5 represents high rainfall/warmer temperatures) as listed in American Wood-Preservers' Association Standard C4 (AWPA 1999). Only 63 utilities were in Zone 4 and 26 were in the most severe zone 5. Utility location can clearly influence pole service life as well as the performance of many initial and remedial chemical treatments.

It has been estimated that between 160 million and 180 million wood poles support the electric transmission and distribution systems in the United States. Our survey respondents represented approximately 25 percent of that total. Most of the 42 million poles in the 244 utility systems that provided species distributions and total pole numbers were southern pine (69%) followed by Douglas-fir (15%) and western redcedar (13%)(**Fig. 1**). Limited numbers of ponderosa and lodgepole pine were also reported. Nearly 63 percent of these poles were treated with oilborne pentachlorophenol, reflecting a long-standing utility preference for this treatment. The remaining poles were treated with chromated copper arsenate (CCA) (16%), creosote (16%), copper naphthenate (3%) and ammonium copper arsenate/ammonium copper zinc arsenate (ACA/ACZA) (1%) (**Fig. 2**). Oilborne chemicals continue to dominate utility systems, although CCA-treated southern pine poles are increasingly more frequent in the southern United States.

NEW POLE PURCHASES

Most utilities purchased fewer than 500 poles per year, a finding that reinforces a survey of utilities in the western United States showing that pole replacement rates at many utilities ranged between 0.5 and 0.7 percent per year (Morrell 1999).

Although wood poles continue to comprise the majority of poles supporting lower voltage lines, many utilities have employed substitute pole materials within the last 5 years (**Fig. 3**). Steel was the most frequently used substitute, while concrete, fiberglass, or laminated wood poles had been employed by 40 to 60 respondents. These responses indicate that utilities are exploring alternative materials, although our survey did not allow us to collect data on the extent of the substitution.

A majority of respondents were also interested in confirming pole quality, as evidenced by the nearly 200 respondents that used either an in-house program or third-party agent to inspect new poles. This suggests that utilities remain concerned about the quality of treater inspection programs. These practices are in sharp contrast to other material purchases, where the manufacturer is expected to provide quality materials without significant purchaser oversight.

A final question under the new pole purchase section concerned pre-treatment procedures to improve the depth of initial treatment. These practices included radial drilling, through-boring, and deep incising that are primarily applied to Douglas-fir, a species with a thin sapwood band surrounding a difficult-to-treat heartwood core (Graham 1983). A majority of respondents (140 utilities) did not use Douglas-fir in their systems, reflecting the abundance of smaller public utilities east of the Rocky Mountains. These utilities typically do not have large numbers of transmission lines where Douglas-fir would be used. Of the remaining 120 respondents, 110 employed one of the 3 groundline pretreatment practices on their Douglas-fir poles. Most utilities claimed to use deep incising on their poles, a somewhat surprising finding, given the limited number of treaters that can apply this method. We suspect that some respondents confused conventional incising (which uses 12- to 19-mm-long teeth on rollers to improve sapwood penetration) with deep incising (which drives 60- to 75-mm-long teeth into the wood). As a result, the incising response must be viewed cautiously. The 60 utilities that incorporated radial drilling or through-boring into their specifications reflect a growing trend among Douglas-fir users to improve treatment in the critical groundline zone. These trends should markedly improve pole service life and alter the manner in which these utilities inspect their poles (Graham 1983).

EXPECTED SERVICE LIFE

Utility consolidations and increasing drives for higher investment returns have encouraged many utilities to evaluate the service lives they obtain from a variety of materials, including wood. At the same time, alternative materials have made service life claims that are, at best, difficult to confirm. For many years, most utilities have used 30 to 40 years as the estimated service life for wood poles. The survey responses reflected these figures for southern pine, ponderosa pine, lodgepole pine, and Douglas-fir (**Fig. 4**). However, most western redcedar users estimated service life of this species to be between 51 and 70 years. Numerous lower-voltage cedar transmission lines across North America that were installed in the 1930s clearly attest to the excellent performance of this species. The tendency for utilities to continue to perceive lower services lives for other species is perplexing in light of advances in inspection and maintenance practices over the past three decades. Western surveys suggesting replacement rates of 0.5 to 0.7 percent per year would place average service life at 70 to 100 years (Morrell 1999). Recent reports on pole service life at several Midwestern utilities support these estimates (Nelson 1999, Stewart 1996). Although these results are promising, it is clear that utilities continue to use outdated information when comparing wood pole service life with that of other materials.

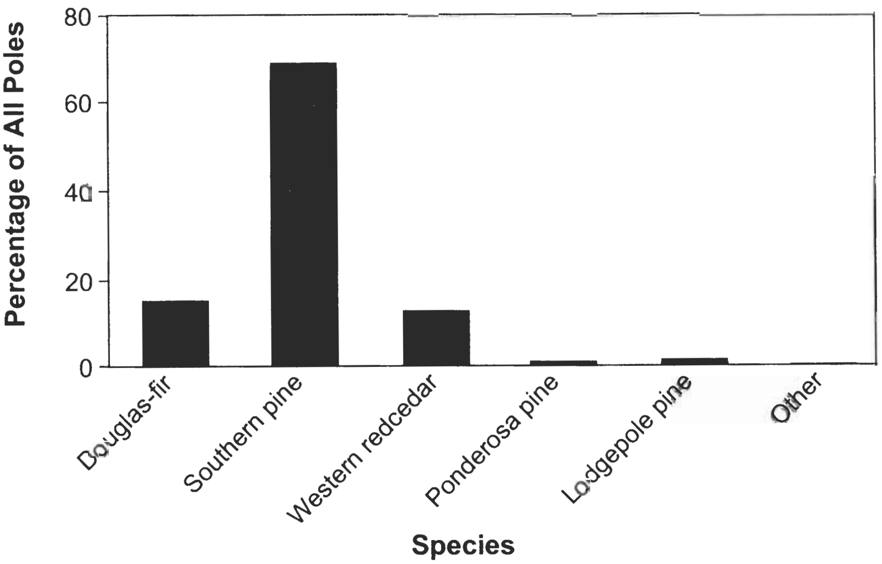

Figure 1. — Wood species composition of the poles in responding utility systems (245 respondents).

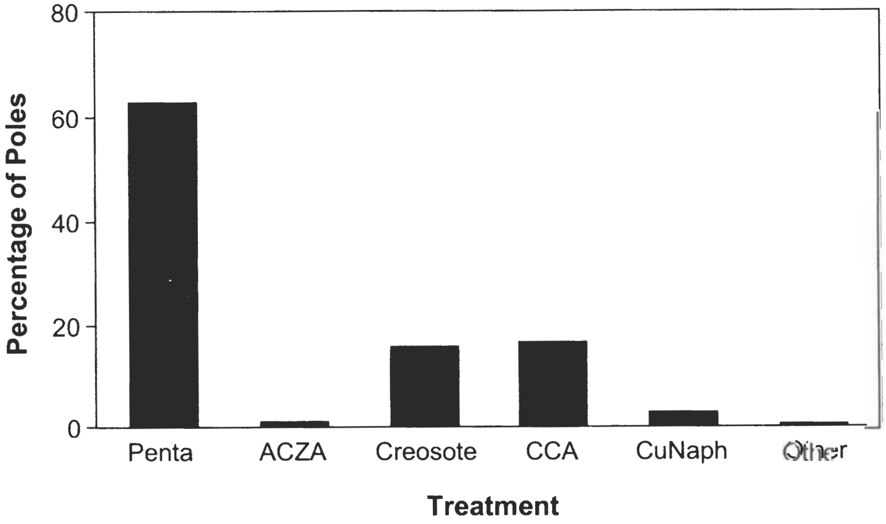

Figure 2. — Frequency of initial preservative treatments in poles in the responding utility systems (256 respondents).

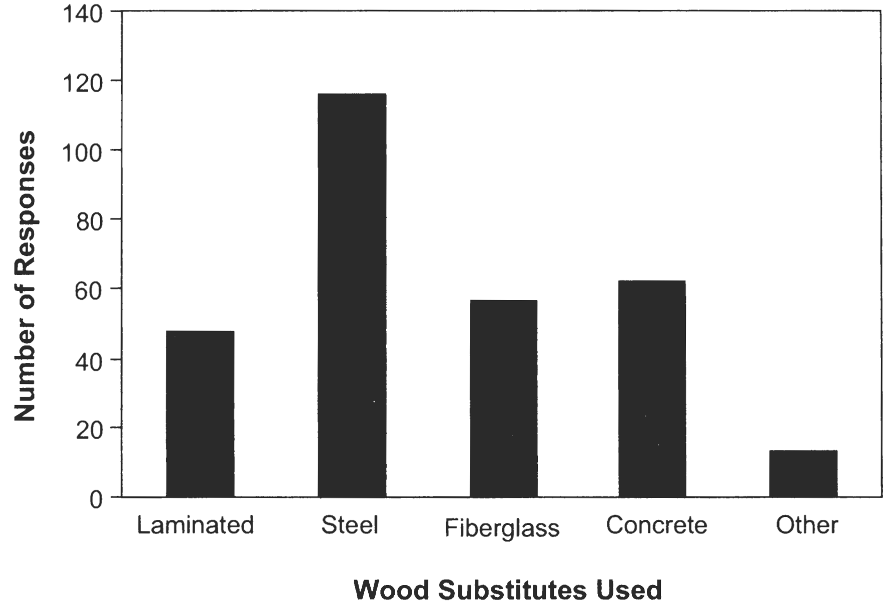

Figure 3. — Frequency that responding utilities purchased a wood substitute in the last 5 years (261 respondents).

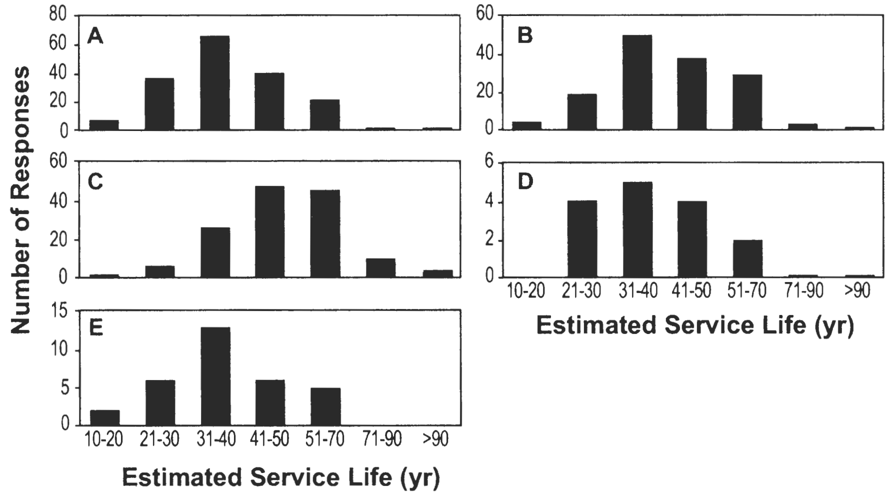

Figure 4. — Expected service of: A) southern pine; B) Douglas-fir; C) western redcedar; D) ponderosa pine; and E) lodgepole pine poles (260 respondents).

This misconception may also influence future utility purchasing decisions. Of the respondents, 48 had used laminated poles, 116 used steel poles, 57 used fiberglass, and 62 used concrete within their systems within the last 5 years. While the survey did not ask what percentage of total purchases were alternative materials, results imply a diversification of pole usage patterns as utility engineers explore the performance properties of wood alternatives.

MAINTENANCE PRACTICES

Inspection cycles. — As expected, there was a wide disparity in inspection frequency among respondents. This disparity was greatest in the distribution systems, where many utilities reported that they had no inspection program for these poles. Transmission poles were inspected every 7.2 years, while distribution poles were inspected every 8.1 years. It is important to remember that this cycle could range from a cursory visual inspection to a complete excavation, sounding, and boring.

The vast majority of utilities reported using combinations of visual inspection, sounding with a hammer, and boring with a drill (**Fig. 5**). These figures differ little from those in the 1983 survey (Goodell and Graham 1983) and reflect a long-term preference for these techniques (Inwards and Graham 1980, REA 1974, Eslyn 1968, Mothershead and Graham 1962). Most of utilities who responded to the current survey bored both above and below groundline, although the number that inspected below the ground was somewhat lower, possibly reflecting the decay risk in many locations. It is common knowledge among utilities in many areas of Zone 1 that decay tends to occur 300 to 450 mm below the ground where moisture conditions are more suitable for fungal growth. Excavation is essential for detecting decay in poles exposed in these regions.

While sounding and boring formed the basis for most pole inspections, some respondents used alternative inspection devices (**Fig. 5**). Seven respondents reported using a moisture meter for pole inspection. While this device will detect wet wood that could be at risk of decay, it does not detect decay. It is possible that these respondents used the moisture meter to assess conformance to post-treatment moisture levels in newly purchased poles rather than for in-service poles. Twelve utilities used the Shigometer for pole inspection. This device measures resistance drops as a twisted wire probe is inserted into a predrilled hole in the pole. The resistance drops signify areas of possible decay. The Shigometer was originally developed for detecting decay in living trees, and has seen only limited application to wood products (Shigo 1980, Shortle et al. 1978). A number of evaluations have concluded that this device is best operated by trained inspectors who can interpret the resulting output (Zabel et al. 1982, Graham and Corden 1980).

Forty-one respondents reported using the sonic device, Poletest®, in their inspection process, with a majority (76%) using the device on Douglas-fir or western redcedar. Although sonic devices have attracted considerable utility interest, it appears that few respondents have incorporated this technology into their systems. Twenty-one respondents reportedly used other inspection tools in their programs, but did not specify the nature of those devices.

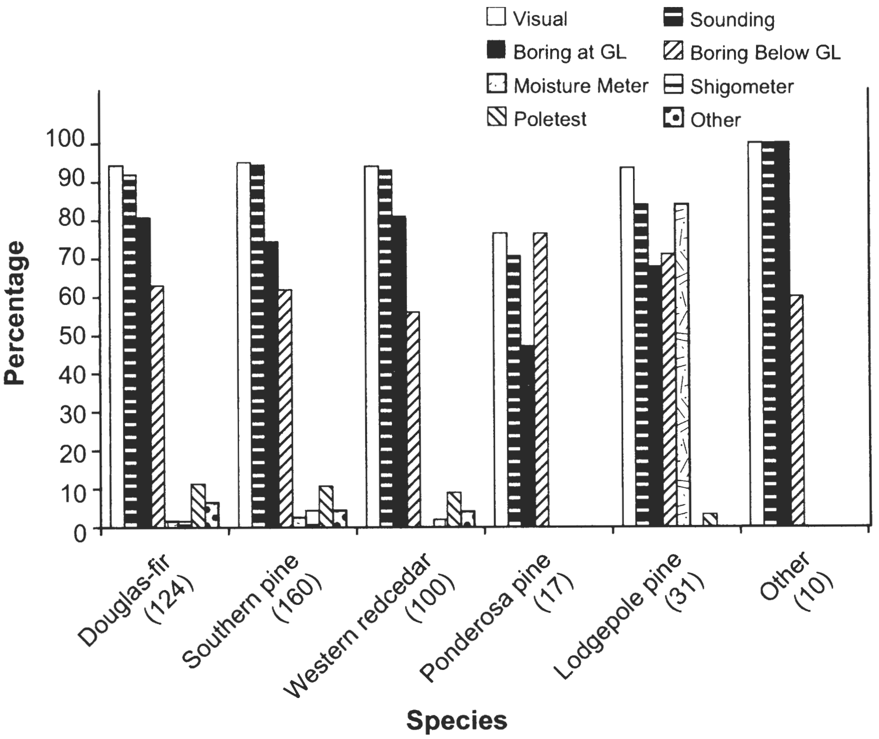

Figure 5. — Frequency that utilities used visual inspection, sounding with a hammer, boring/drilling at or below the groundline (GL), moisture meter, Shigometer, or Pole Test as a part of their pole inspection procedures for poles of various wood species.

The past decade has witnessed the introduction of a number of microdrilling or sonic devices that seek to provide supplemental information to the inspector. Despite these efforts, however, it appears that most utilities are unwilling to change their inspection procedures to incorporate such devices. It is unclear whether the delayed adoption of new technology represents the conservative nature of the industry or dissatisfaction with the results these devices provide.

Carpenter ants. — Carpenter ants can be an important problem in some regions of the United States, particularly where utility right-of-ways pass through forested areas. Unlike termites, which can usually be controlled by void treatments into their galleries, carpenter ants are more mobile and therefore capable of moving out of the remedially treated zone to attack other portions of the pole. Approximately 1.4 percent of poles in the responding utilities experienced carpenter ant attack. The damage, however, was often concentrated among utilities that had extensive territories in more heavily forested areas. Most utilities (61% of respondents) reported that they had no treatment in their specifications for carpenter-ant control (**Fig. 6**). Presumably, utilities that reported carpenter-ant attack replace poles once the damage exceeds the utility's replacement criteria. The remaining respondents used a variety of treatments including Hollowheart, "Fume", Dursban, sodium fluoride rods, copper naphthenate, and Patox. While carpenter ants do not appear to be a nationwide utility issue, it is clear that they are locally important. It is unclear, however, if the level of damage is sufficient to support specialized products for preventing attack by these insects.

Woodpeckers. — Like carpenter ants, most woodpecker damage appears to be closely related to the proximity of a line to a forested area. However, even a small grove of trees can serve as potential woodpecker habitat that could increase the likelihood of pole attack. Woodpeckers attack wood poles for a variety of reasons, including resting, feeding, and nesting, and not all species attack poles. Woodpeckers damaged an estimated 5.75 percent of poles in the responding utilities, a figure suggesting that the estimated cost of this damage ($5,272,200/yr.) seems relatively low. Many respondents (102/206 or 49.5%) used epoxy fillers to control woodpecker attack, while 56/206 (27%) used hardware cloth to prevent damage (**Fig. 6**). A limited number of utilities used fiberglass wraps (6.3%), while 35 respondents used "other" methods, but did not identify those methods.

REMEDIAL TREATMENTS

Respondents were asked to identify all of the remedial treatments used in their systems (**Fig. 7**) and then assess their level of satisfaction with each chemical (**Figs. 8** and **9**). These treatments can be divided into external systems for controlling soft-rot attack and internal systems for controlling internal decay. Over 40 percent of the respondents used Osmoplastic for external decay control, while nearly 30 percent used one of three copper naphthenate-based formulations (**Fig. 8**). Although the contents of Osmoplastic have changed in the intervening 17 years, the percentage of respondents using this system has changed little from the 37 percent in 1983 (Goodell and Graham 1983). Nearly 20 percent of respondents used Patox, which we presumed to be Patox II, a sodium fluoride-based system. The results indicated that most utilities have largely shifted from using pentachlorophenol-based external treatments as a result of changes in licensing requirements for the use of penta-based materials.

While chemical usage patterns have changed, it is also clear that the respondents were generally satisfied with the performance of these systems. Most utilities perceived the performance of the currently specified systems to be acceptable or better. Interestingly, Osmoplastic received the most excellent responses of any chemical evaluated (nearly 30% rated this chemical as an excellent performer). Similarly, utility perceptions about safety mirrored performance perceptions. Most importantly, few respondents viewed the chemicals as being unsafe.

Utilities rated their perceptions on five internal remedial treatments: metham sodium, chloropicrin, MITC-Fume, sodium fluoride rods, and fused boron rods (**Fig. 9**). Comparisons between the new data and that generated in 1983 were not possible because the original survey lumped all fumigants together and neither boron nor fluoride rods were available at that time. A majority of respondents in the current survey used one of the three fumigants. Interestingly, however, MITC-Fume was the most commonly used internal treatment followed by metham sodium and chloropicrin. Until the introduction of MITC-Fume in the early 1990s, metham sodium was the dominant fumigant used for internal decay control. Chloropicrin was traditionally used in overland transmission lines away from inhabited areas owing to its difficult handling properties. It would appear that MITC-Fume, which is a solid at room temperature and is encapsulated in aluminum tubes for safe handling, has taken market share from both metham sodium and chloropicrin.

Boron and fluoride rods are both relatively recent entries into the U.S. utility market, although both have been commercially used in other countries. Both systems are water soluble and easily handled. They have relatively mild language on their labels that does not require that the applicator have an applicator license for installation. These chemicals, however, work more slowly than fumigants. It would appear that utilities are incorporating diffusable rods into their systems, but the pace of product adoption is relatively slow. The slow rates of adoption may reflect perceptions about performance and safety. Most utilities felt that MITC-Fume, metham sodium, and chloropicrin provided good-to-excellent performance, and a high percentage of these respondents felt that MITC-Fume and chloropicrin provided excellent protection. Conversely, few respondents felt that either boron or fluoride rods provided excellent performance. These perceptions nearly reversed when safety was the primary concern. Most respondents rated the rods as excellent in terms of safety, while few perceived that either metham sodium or chloropicrin were in the excellent category. It is interesting to note that MITC-Fume proved to be intermediate in these categories, with many utilities rating both safety and performance favorably. This presumably accounts for the high number of utilities who currently specify this chemical.

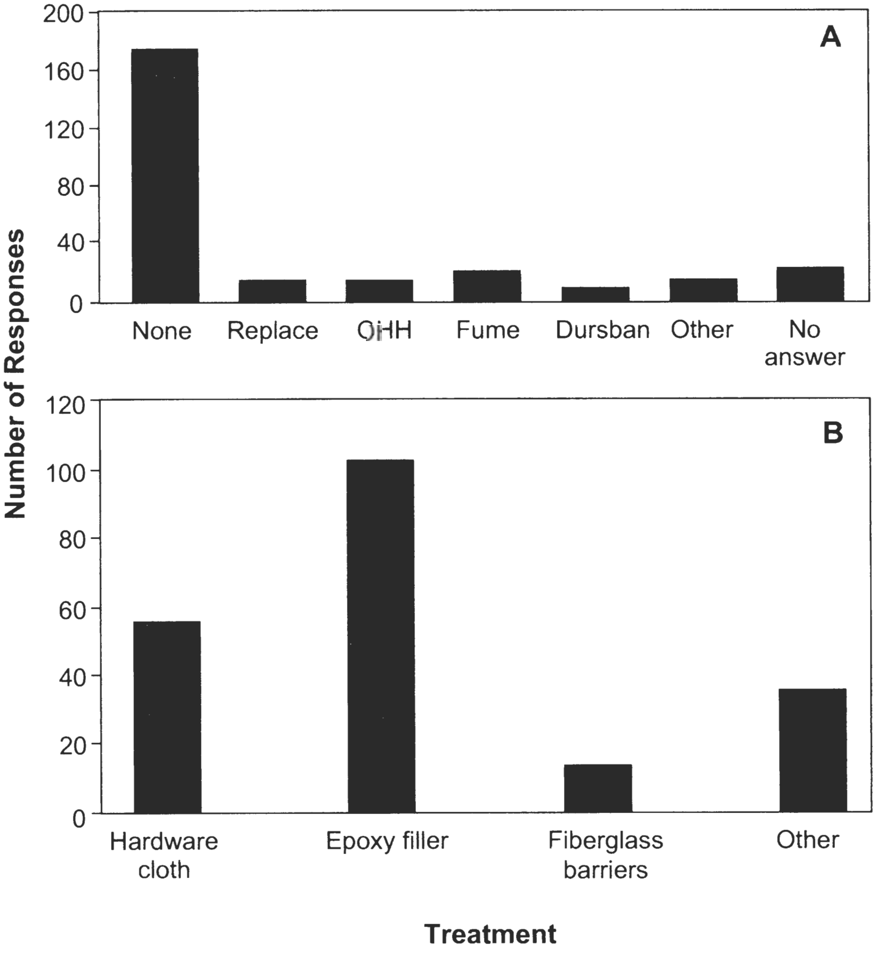

Figure 6. — Frequency of utilities using various remedial systems for: A) carpenter ant infestation or B) woodpecker attack of wood poles (242 respondents).

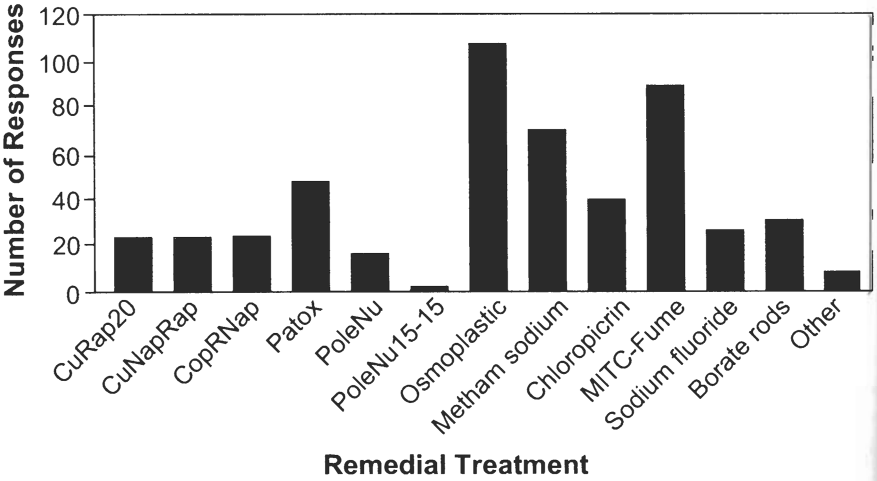

Figure 7. — Frequency of usage of various remedial treatments among 260 responding utilities.

Training. — An inspection and maintenance program is only as effective as the degree to which the personnel understand the nature of the materials and the characteristics of the chemicals. A majority of respondents listed electrical en-

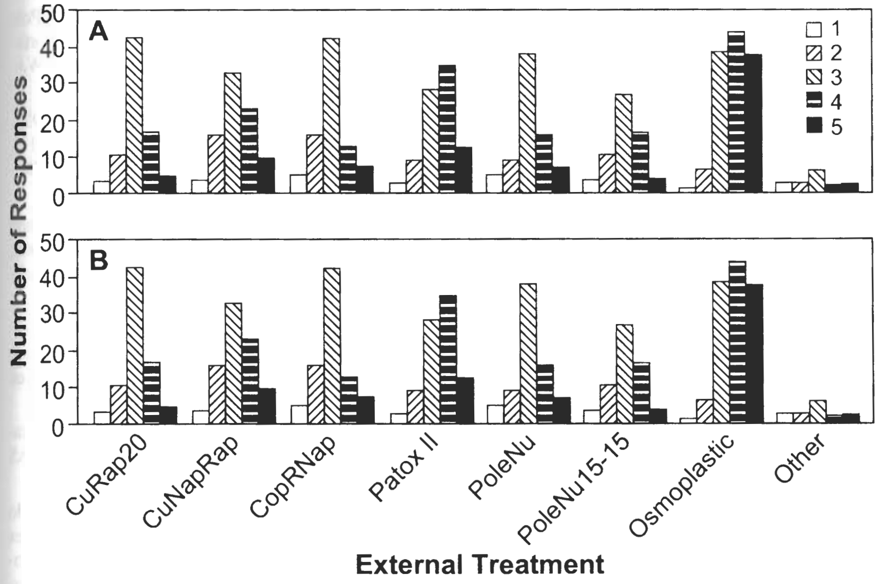

Figure 8. — Utility perceptions concerning: A) performance and B) safety of various external remedial treatments for arresting decay in wood poles (260 respondents; 1 indicates poor and 5 indicates excellent).

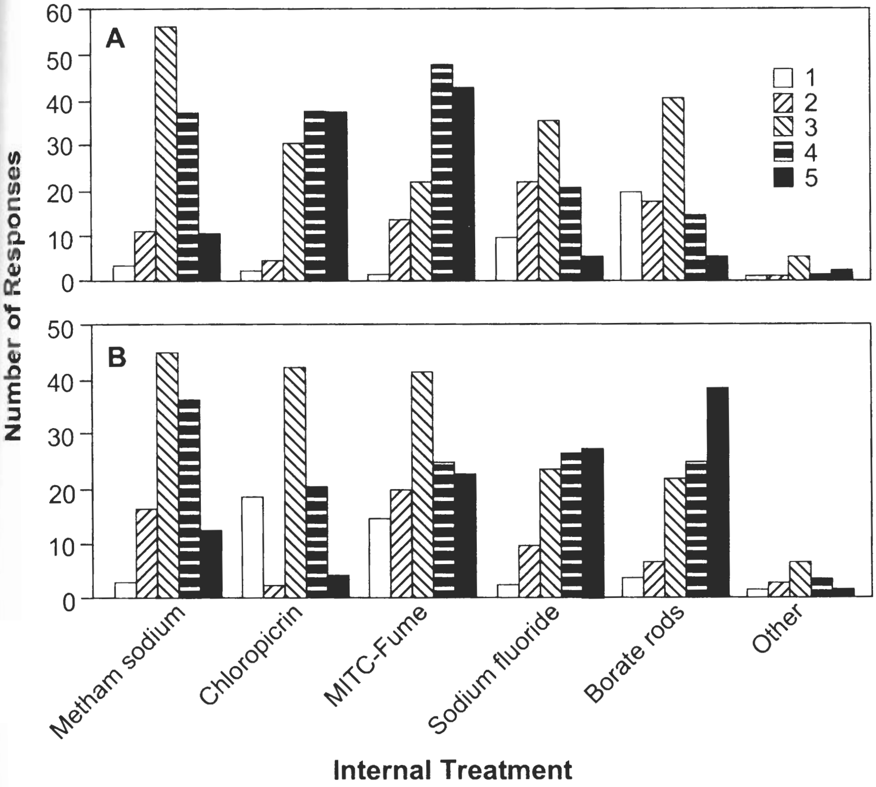

Figure 9. — Utility perceptions concerning: A) performance and B) safety of various internal preservative pastes or bandages used to arrest external decay on wood poles (260 respondents; 1 indicates poor and 5 indicates excellent).

gineering as their primary field of training (124/260) suggesting that they came to their jobs with little in the way of formal training in wood as a material or the treatments used to protect wood (**Fig. 10**). Only 16/260 respondents had forestry training and only 4 of these were trained in forest products, an astoundingly low level of initial training given the economic importance of wood in most utility systems. The low initial knowledge level that many utility personnel bring to the job implies a need for training and information to educate personnel on wood-related issues.

One concern that did not emerge from the survey was that utilities were becoming increasing isolated as they sought to maximize their internal knowledge, while minimizing transfer of this knowledge to other utilities who might eventually compete for business. This may reflect the relatively early stage of deregulation in many states. We may expect to see less interaction between utilities as these companies increasingly compete for customers.

CONCLUSIONS

The results suggest that many utility practices remain relatively unchanged from those found 17 years ago. Utilities clearly see wood as an important component in their systems, although their perceptions on service life of wood deserve some reconsideration. Most utilities have regular inspection programs and appear to be satisfied with the chemicals they use to arrest decay. The study also suggested a need for supplemental training to assist engineers who lack initial training in wood as a material.

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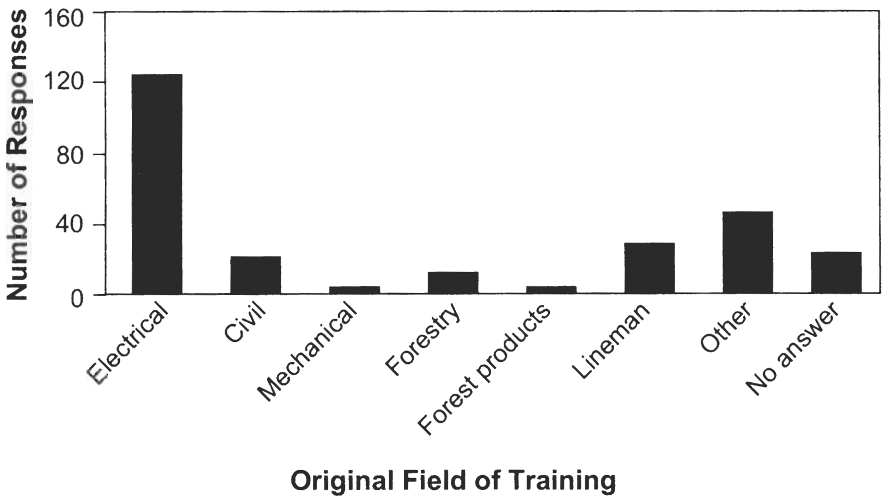

Figure 10. — Primary field of training for respondents (261 respondents).

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