DUTCH ELM DISEASE CONTROL: SANITATION IMPROVED BY GIRDLING INFECTED ELMS[1]

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Abstract. For 5 years three alternative treatments to improve the efficacy of municipal sanitation programs for controlling Dutch elm disease (DED) were compared to the sanitation practice in which one disease survey was made each year and diseased elms were removed in late fall and winter. Significant reductions in DED were obtained in treatments where three disease surveys were conducted each year and diseased elms were promptly removed. In the treatment in which diseased elms were girdled, fewer elms became diseased in subsequent years. Spraying the trunks and major branches of diseased elms with hydraulic applications of methoxychlor did not significantly improve DED control.

Dutch elm disease (DED) is a vascular wilt caused by the fungus *Ceratocystis ulmi* (Buisman) C. Moreau. The disease is introduced into the tree through twig-crotch feeding wounds made by two bark beetles: *Scolytus multistriatus* (Marsham), the smaller European elm bark beetle, and *Hylurgopinus rufipes* (Eichhoff), the North American elm bark beetle. The pathogen is also transmitted through root-grafts from diseased to healthy trees.

The DED problem is difficult to deal with in urban areas because of the heavy concentrations of both public and private elms and because these elms were planted close together. Often, sanitation — the identification and removal of diseased trees — is neither timely nor coordinated and is not begun until some diseased elms are heavily colonized by the fungus and the beetles have emerged. Thus, municipal arborists, particularly those who are charged with managing large numbers of elms under a variety of ownerships, continue to have difficulty minimizing disease losses.

Studies demonstrating the efficacy of sanitation in controlling DED have been reported by Marsden (1953), Miller and others (1969), Neely (1975, 1978), Van Sickel and Sterner (1976), and Barger (1977). But further improvement in sanitation is needed to reduce both amount of root-graft spread and numbers of bark beetle vectors between the time diseased elms are detected and the time they are removed. From 1974 to 1978, we tested alternative treatments to improve the efficacy of municipal sanitation practices.

Methods and Procedures

Tree and plot selection. Every curb-side American elm, *Ulmus americana*, within a 6.6 mi^2 (17 km^2) contiguous area of Detroit, Michigan, was included in this study (Fig. 1). The average elm diameter at breast height (1.5 m) was 23.5 inches (60 cm), and the average height was 65 feet (20 m). The area was divided into 13 plots (1 not used) that each between 526 and 696 elm trees. Treatments were classified and randomized by density of elms. Each of the four sanitation treatments were applied to three plots with one plot in each of three density classifications: 0.9 to 1.4 elms per acre, 2.1 to 2.5 elms per acre, and 2.7 to 3.1 elms per acre. As part of the city's ongoing DED control program, all elms were sprayed by mist blower each spring with 12.5 percent methoxychlor emulsion at about 0.5 gallons (1.9 L per tree). In prior years, surveys to detect diseased elms in the study area had been conducted once in August, and these elms were removed later during the dormant season. This program was maintained in all surrounding areas during the test.

Treatment, surveys, and removals. Treatments were applied to diseased elms only without regard to the origin of infection or the percentage of crown showing symptoms.

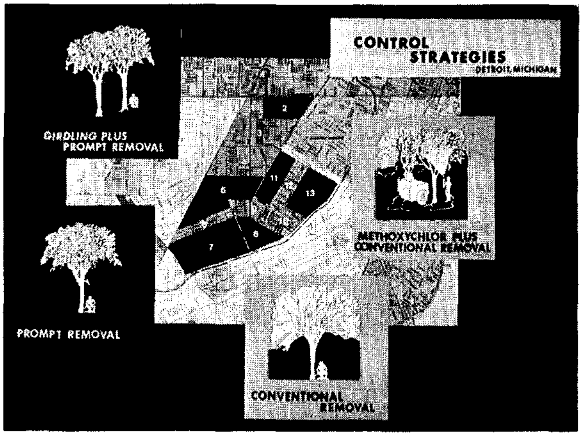

Figure 1. Experimental area showing sanitation control strategies in Detroit, Michigan.

Treatment 1. Immediate girdling plus prompt removal (removal within 20 work days) (Fig. 2). Diseased elms were girdled to reduce root-graft spread of DED. Girdling intercepts the fungus and delays its migration into the root system long enough to allow for tree removal. Immediate girdling also should make elms more attractive for bark beetle attack so the trees also should serve as effective beetle traps.

Treatment 2. Prompt removal only (Fig. 3). This treatment may be comparable to girdling plus prompt removal in reducing the spread by DED by similarly intercepting the fungus and by destroying beetle brood material. It was included to test for possible differences.

Treatment 3. Immediate methoxychlor spray plus conventional removal during the dormant season (Fig. 4). Because elm bark beetles are attracted to diseased and dying elms (decadent elms) where breeding and gallery construction occurs, spraying the trunks and main branches of these elms with methoxychlor may prevent much beetle colonization. Furthermore, if these elms were not removed during the beetle season, they could serve as effective traps.

Treatment 4. Conventional removal only (Fig. 5). Because many municipalities continue to remove diseased elms only during the dormant season, we measured the other three techniques against conventional removal.

Surveys. Each year we conducted DED surveys on all elms in Treatments 1, 2 and 3 during the second week of June, third week of July, and fourth week of August. We drove up and down each street, visually examined the trees from both directions, and determined the approximate percentage of crown involvement for diseased elms.

Diseased elms in Treatment 1 were girdled immediately upon detection during each survey. We made two cuts about 4 inches (10 cm) apart at 3 feet (1 m) above ground level with a chain saw (Fig. 6). After the bark was removed between these cuts, we visually examined the exposed bole for xylem staining. The girdle was then completed by making a third center cut about 1.5 inches (3.8 cm) deep.

In Treatment 3, the boles and major branches of diseased elms were sprayed to runoff with 12.5 percent methoxychlor emulsion at about 3 gallons (11.3 l) per tree by using a John Bean 500-G[1] hydraulic sprayer (No. 5 disc; 250 psi) on the day following detection.

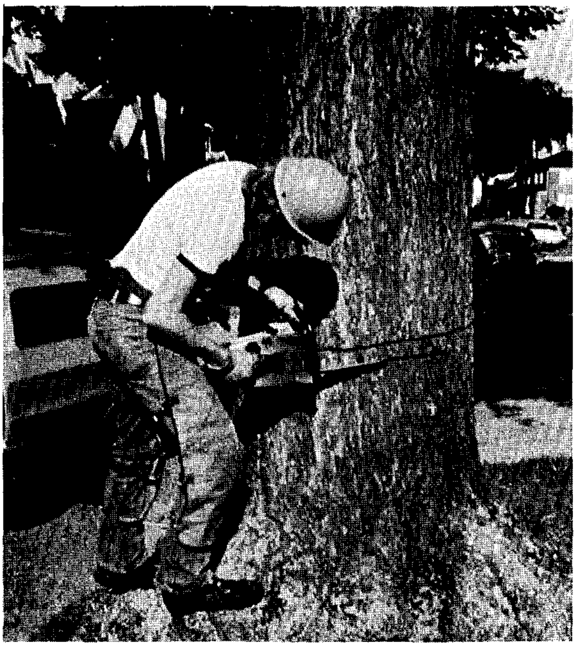

Figure 2. Immediate girdling of a diseased American elm.

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

Figure 3. Prompt removal of an American elm with Dutch elm disease.

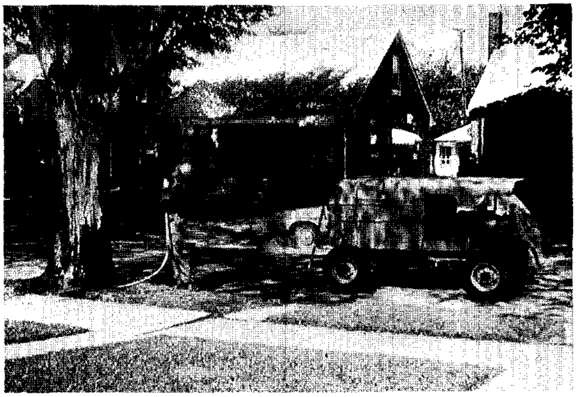

Figure 4. Hydraulic sprayer application of methoxychlor emulsion to the trunk and major branches of a diseased American elm.

Figure 5. Dormant season removal of an American elm with Dutch elm disease.

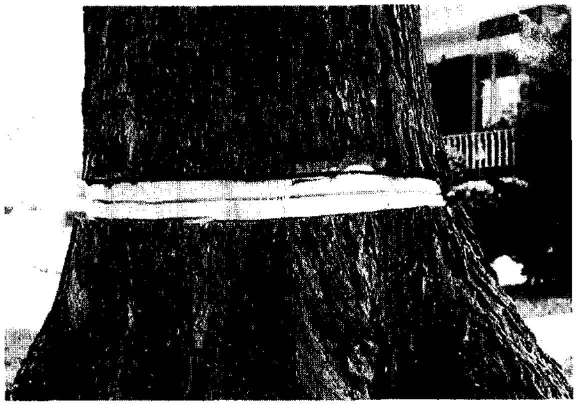

Figure 6. Completed girdle of an American elm showing bole staining caused by the Dutch elm disease fungus.

Removals. Diseased elms in Treatments 1 and 2 were removed within 20 work days after detection. Those in Treatment 3 and 4 were removed during the dormant season but always before April 15th of each following year. Trees removed for reasons other than DED were dropped from the study.

Results and Discussion

For the three treatments requiring three disease surveys, we found that 53 percent of the diseased elms showed crown symptoms of about 1 to 19 percent; 25 percent showed 20 to 49 percent crown symptoms; and 22 percent showed 50 percent or more. We visually determined that about 28 percent of the diseased elms had been infected by root-grafting in the girdling plus prompt removal plots, 30 percent in the prompt removal plots, 35 percent in the methoxychlor plus conventional removal plots, and 33 percent in the conventional removal plots. Only 19 of the girdled elms showed no visible DED bole staining on the girdled area.

From one year to the next, the percentage of disease incidence fluctuated within and among all four sanitation treatments (Table 1). But the patterns of elm survival resulting from the four treatments were our primary concern (Fig. 7). Survival rates of elms during the 5 years of the study for each treatment were computed and compared in their entirety by the chi-square procedure of Mantel (1966).

These analyses showed that the survival-time patterns of elms that received the methoxychlor

Table 1. Cumulative number of diseased elms, alive elms, and percentage Dutch elm disease incidence since initiation of study in Detroit, Michigan, 1974-1978.

	1974		*1974-75*		*1974-76*		*1974-77*		*1974-78*	
Treatment	*DED*	*Alive*	*DED*	*Alive*	*DED*	*Alive*	*DED*	*Alive*	*DED*	*Alive*
Girdling plus prompt removal	113 5.6%	1923	184 9.1%	1845	279 13.8%	1743	358 17.7%	1664	497 24.6%	1525
Prompt removal only	85 4.7%	1735	155 8.6%	1656	272 15.1%	1532	377 20.9%	1427	489 27.1%	1315
Methoxychlor spray plus conventional	116 6.4%	1700	232 12.8%	1579	430 23.8%	1380	566 31.3%	1244	714 39.4%	1096
Conventional removal	110 6.2%	1659	208 11.8%	1554	410 23.3%	1352	556 31.5%	1206	748 42.5%	1014

plus conventional removal treatment were similar to the survival-time patterns of the conventional removal only treatment. However, elm survival was greatly increased in plots where diseased elms were removed promptly. Mantel's chi-square procedure showed that a highly significant difference existed between the survival-time patterns of the prompt removal treatment versus the conventional removal treatment ($X^2=95.5$, $P<0.001$). Further improvement in elm survival was obtained by the girdling plus prompt removal treatment. Mantel's procedure showed a significant difference between this treatment and prompt removal alone ($X=5.69$, $P<0.025$). Tree density had no significant effect on the outcome of these DED control treatments as similar results were obtained in plots with sparse, medium, and dense elm stocking.

Control effectiveness does not manifest itself immediately; it builds over a period of years. Evidently with DED, this process requires several years after controls are initiated. This is evidenced by increasing differences in survival rates (Fig. 7) as well as the larger chi-square values obtained as our study progressed (Table 2). The variation in DED incidence among replicates within treatments is large, and this requires extraordinary differences between treatment averages to produce statistical significance.

To find which treatments were significantly different each year, the cumulative data for active control measures were compared to the conventional removal alternative with the chi-square test of independence (Table 2). Those individual treatments that proved significantly better than conventional removal thus were identified before the study was completed. We were able to anticipate potentially worthwhile treatments and watch their effectiveness progress. For the prompt removal treatment and the girdling plus prompt removal treatment versus the conventional treatment, we expect an increasing level of significance to continue until a steady state is achieved. This may take several additional years beyond our study.

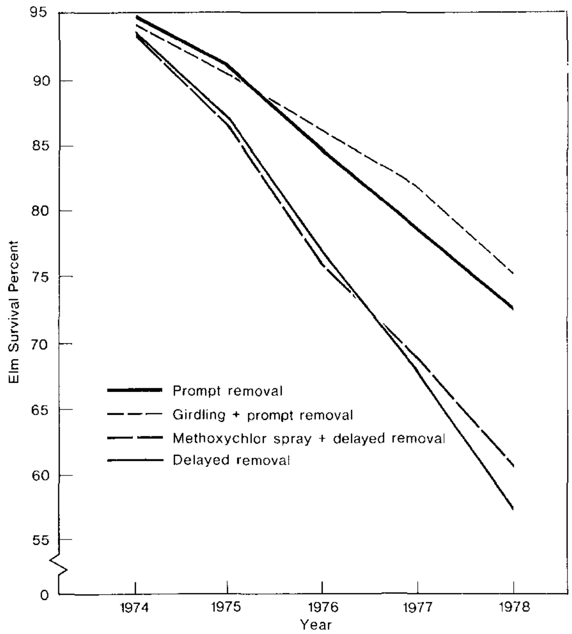

Figure 7. Survival of American elms under Dutch elm disease sanitation treatments in Detroit, Michigan, 1974 to 1978. Percentage based on initial population.

Table 2. Results of chi-square tests of independence computed for Dutch elm disease sanitation treatments as elm losses progressed during the 5 year study.

Comparison of sanitation treatments	*1974*	*1974 through — 1975*	*1976*	*1977*	*1978*
Girdling plus prompt versus prompt removal	1.53	2.03	1.58	6.26*	3.19[a]
Girdling plus prompt versus conventional	0.77	7.62**	56.71**	98.58**	136.22**
Prompt removal versus conventional	2.22	10.31**	38.67**	52.40**	92.65**
Methoxychlor spray versus conventional	0.04	0.81	0.12	0.03	3.33[a]

[a]Significant at 10-percent level.
*Significant at 5-percent level.
**Significant at 1-percent level.

Conclusions

This study confirms that a program of prompt removal of diseased elms during the growing season achieves a significant improvement in saving elms over conventional removal. Further improvement is obtained by girdling plus prompt removal of diseased elms. Municipal arborists now have an additional sanitation technique that shows promise of saving more elms over a greater number of years.

Acknowledgments

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