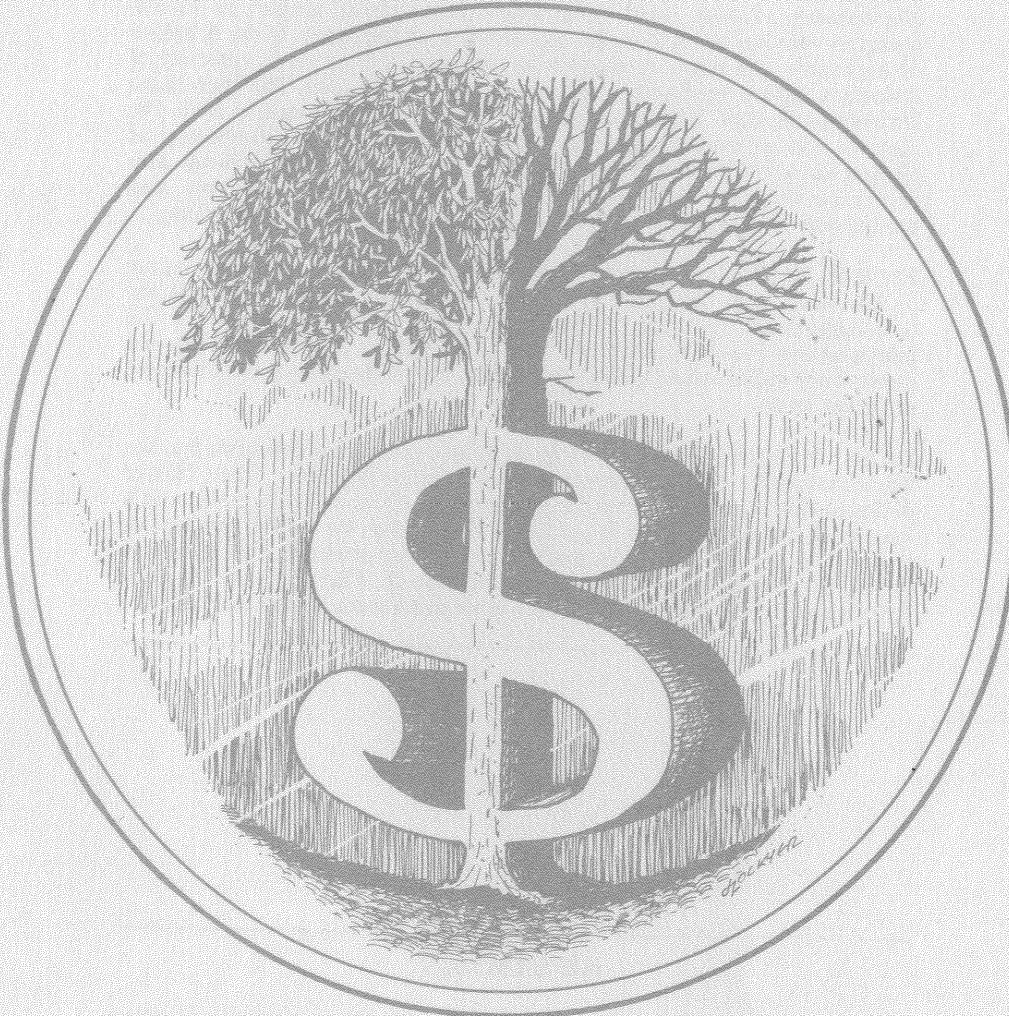
DUTCH ELM DISEASE CONTROL:

INTENSIVE SANITATION AND SURVEY ECONOMICS



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ABSTRACT

Recent research has shown that prompt removal of diseased elms reduces the incidence of Dutch elm disease more than the sanitation practice that allows diseased elms to remain standing into the dormant season. The key to prompt removal is repeated surveys to detect diseased elms as early as possible. Intensive sanitation can save more elms and cost less than the more conventional sanitation practice. A 3-year case history demonstrates savings of 25 percent in total cost and an additional 92 elms per thousand.

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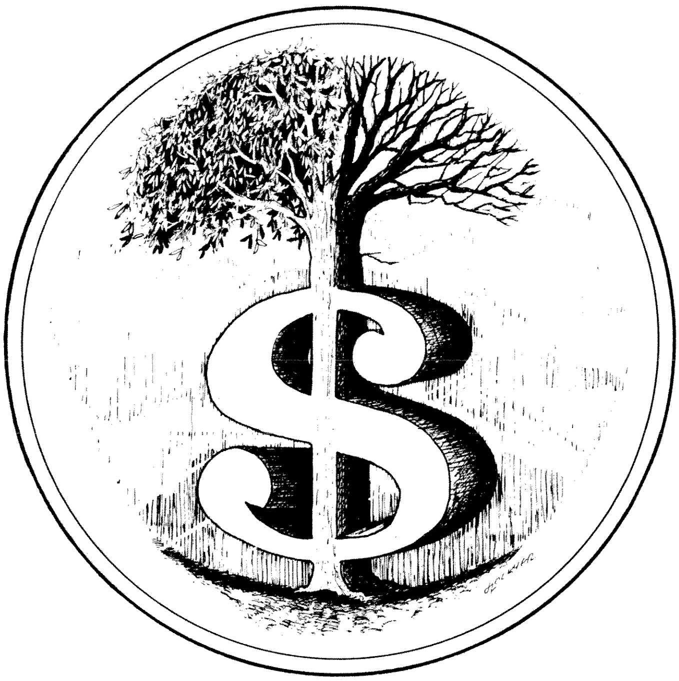

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DO THE RIGHT THINGS AND DO THEM RIGHT

SANITATION, the removal and disposal of diseased elms and any elm wood that can be colonized by bark beetles, has long been the mainstay of successful Dutch elm disease control programs. Dead and dying elm wood serves as a reservoir for the disease fungus and the elm bark beetles that spread it. Eliminating this material reduces both the beetle population and the pathogen.

Prompt removal of diseased elms has been a recommended sanitation practice for many years (Whitten 1956; Neely 1961, 1975). Diseased trees found during the growing season (June 1 to August 1 in some areas) are removed within 30 days after the first symptoms were observed. Those found in late summer (after August 1) are removed during the dormant season so that by late spring (May 1) of the following year all diseased trees have been removed. Several communities have achieved good control by following this program (Marsden 1953, Miller and others 1969, Neely 1972, Van Sickle and Sterner 1976).

Many communities have Dutch elm disease control plans that call for such a sanitation program, but have found it difficult to carry out (Miller and others 1969). Their conventional sanitation program consists of a survey in mid- or late summer to detect diseased elms and removal of those trees during the fall and winter. Their goal is to have all the diseased trees removed before bark beetle emergence the following spring.

The early sanitation recommendations were intuitive, based on biological principles and some knowledge of the disease and its spread (Neely 1975). A recent study by Barger (1977) has shown that a more intensive sanitation program resulted in better control than the conventional sanitation practice. His intensive program consisted of frequent surveys and removal of diseased elms within 20 working days after symptoms were observed. All trees known to be diseased were removed before the dormant season, a departure from the previously recommmended sanitation practice.

Frequent surveys are the key to intensified sanitation. The success of such a program requires that diseased elms be detected and slated for removal as soon as the first symptoms are detected. This requires an efficient survey procedure.

Before organizing a new Dutch elm disease program or changing the emphasis of an ongoing one, a manager should consider the role that survey plays in the overall program. In this paper we present evidence of the cost of detection and its relation to the effectiveness of intensive sanitation. We have used a strictly financial approach to assess the impact of survey and tree-removal costs on the municipal budget. By focusing on sanitation as a control method we do not mean to imply that it is a cure-all for Dutch elm disease. It is the one measure however, that is basic to a great many successful control programs.

The Situation

In the community where we did this study (Detroit, Michigan), sanitation meant detecting diseased elms in one survey during the growing season and removing them during the dormant season. This community had lost 5 percent or more of its elms annually.

A large-scale pilot test involving 7,000 city-owned street-side elms was initiated in a section of this community in 1974 to find out whether a more intensive sanitation program would reduce the incidence of Dutch elm disease (Barger 1977). The study area was divided into 12 large adjoining blocks of about 600 trees each. All elms were sprayed with methoxychlor by mist blower in the spring of each year. Half of the blocks were selected at random to receive conventional sanitation, the remainder received intensive sanitation.

The intensive sanitation program consisted of surveys in mid-June, mid-July, and late August (the exact dates depended on local weather patterns). They were planned to locate elms that had been infected in the late fall of the previous year, or after the spring and summer beetle flights. Diseased elms were removed within 20 work days after the disease was detected. Survival of elms in each block was recorded in each of the 3 years of the experiment: 1974, 1975, and 1976.

The Survey Method

Three surveys were made each year in those blocks selected to receive intensive sanitation, each visually conducted by two experienced individuals. One drove a car slowly along the streets while the other paid strict attention to spotting Dutch elm disease symptoms. Only the street trees to the right of the observer were inspected, so each street was traversed twice to observe all elms. When a tree that showed disease symptoms was spotted, the car was stopped to make sure. If the diagnosis was confirmed visually, the tree was marked for removal.

Survey Analysis

Records of gross job time (Worley and others 1965) were kept for these surveys to see how expensive they were. The number of trees surveyed per hour and the number of diseased trees found was determined daily for each block. A total of 12 job times was evaluated for the initial survey, 9 for the second survey, and 8 for the third survey. The number of trees per mile of city street in each study area was determined from city maps and related to the survey times. These data were subjected to regression analyses.

Survey Performance

In the areas we surveyed, the number of elms per mile[1] along the streets varied from 24 to 80. The average distance between elms at the density of 24 per mile is 220 feet; at 80 per mile it is 66 feet. The cross streets had fewer elms than the main streets. At the lower densities the elms tended to be in clumps resulting from inroads of the disease, whereas at the higher densities they were more uniformly spaced.

We found that the first survey of the season took the most time. The disease rate ranged from 2 to 14 percent among study areas. However, the survey speed (trees/hour) was not directly related to the disease rate; it depended on the number of trees per mile surveyed (Fig. 1). As the number of trees per mile surveyed increased from 24 to 80, the number of trees surveyed per hour increased from 107 to 180.

Subsequent surveys in mid-July and late August were completed more quickly than the initial survey. Fewer elms were found to be diseased, the rate in the study areas ranging from zero to 2 percent. In these later surveys, the number of diseased elms observed was a factor in the time required. As in the initial survey, the number of trees per mile of street surveyed also affected the number of trees surveyed per hour. This relationship for disease rates of 0, 1 and 2 percent is illustrated in Figure 2. The regression lines are steeper, indicating that the later surveys were more sensitive to the number of trees per mile surveyed than the first survey of the season. The spacing between the regression lines in Figure 2 shows that for each percent increase in the disease rate up to 2 percent, about 73 fewer trees per hour were surveyed.

Survey Costs

The 1972 costs of the individual jobs included in the Dutch elm disease control programs of 39 municipalities were compiled by Cannon and Worley (1976). The costs of survey ranged from 15 to 30¢ per tree per year with the average being 20¢ per tree. We have brought these figures up to date, correcting for inflation during the 5-year period by using the wholesale price index; in terms of March 1977 dollars these costs would be from 24 to 48¢ per tree with an average of 32¢ per tree surveyed each year.

If we wanted to estimate the costs of the surveys made for the intensive sanitation program in our test community, we could use the cost data given above and the performance data from Figures 1 and 2. For example, the number of trees per mile of street in our test blocks averaged 57. Using the equation given in Figure 1, we find that in the initial survey of the season we could survey an average of 150 trees per hour. Multiplying 150 trees by the average cost of 32¢ per tree surveyed gives a product of $48 per hour.

The second survey of the season, made in mid-July, revealed that about 2 percent of the remaining elms showed symptoms of the disease. Using our average of 57 trees per mile (X_1) and a 2 percent disease rate (X_2) in the equation shown in Figure 2, we find that we could survey about 248 trees per hour. We assume that the hourly cost of this survey would not be any greater than that of the initial survey. Using the cost of $48 per hour, we find that the average cost of the second survey would be 20¢ per tree.

[1] 1 mile = 1.609 kilometers, 1 foot = 30.48 centimeters.

Figure 1.—Trees surveyed per hour as a function of the number of trees per mile of city street surveyed—initial survey.

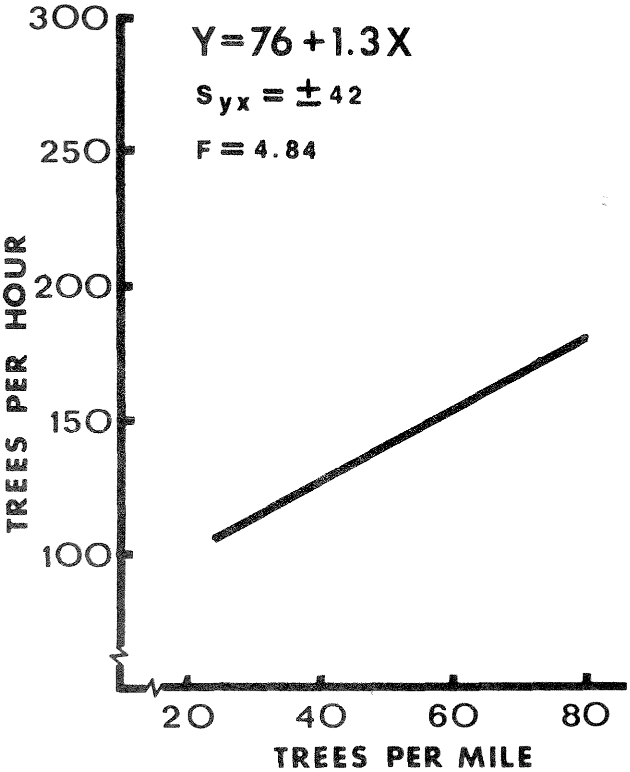
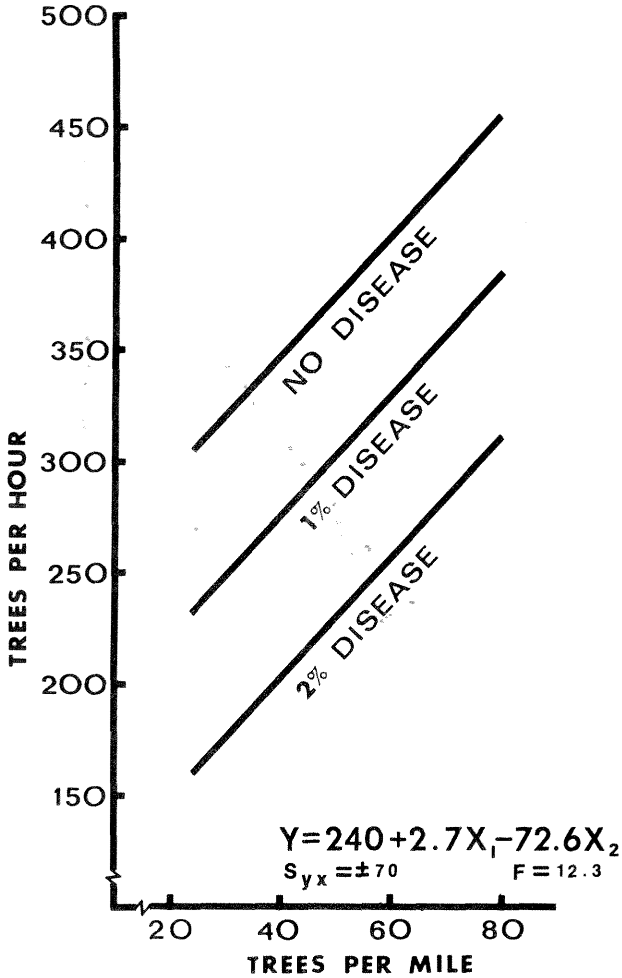


Figure 2.—Trees surveyed per hour for each of three disease rates, as a function of the number of trees per mile of city street surveyed—subsequent surveys.

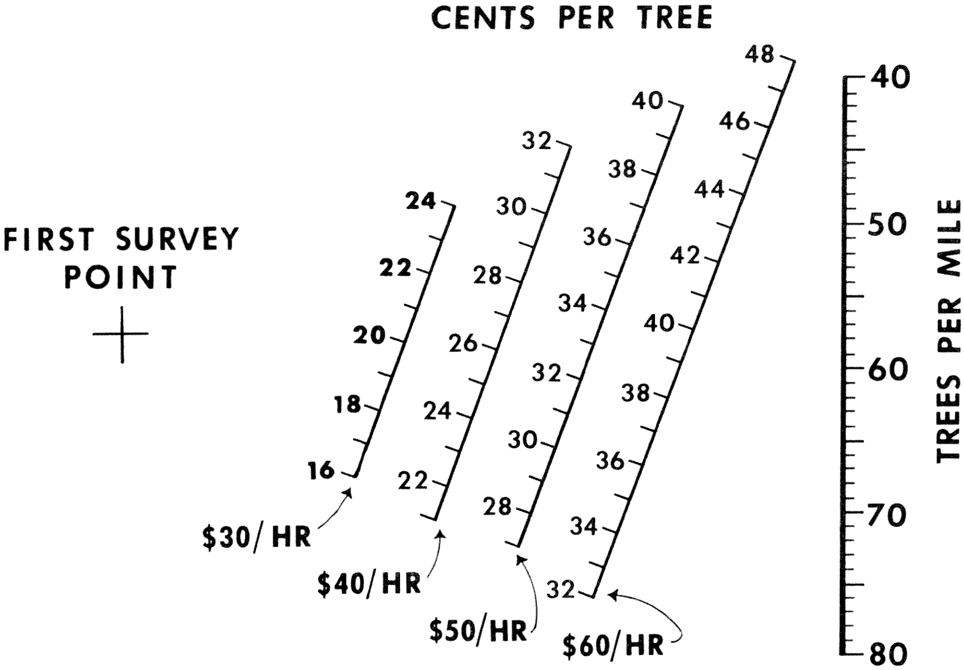


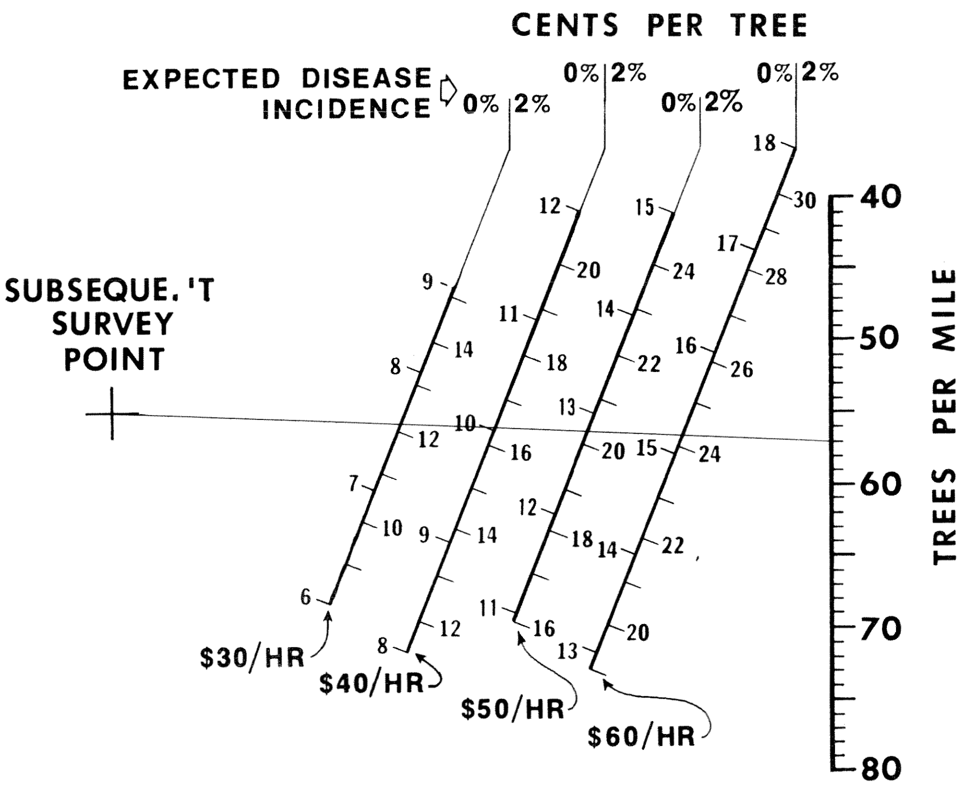
In the final survey, made in mid-August, we found that the average disease rate was about 0.6 percent. Repeating the procedure used for the second survey, we can show that the average cost of the third survey would be about 14¢ per tree.

How can this information be used for planning purposes? The costs we used in our example were determined by the average tree density in our test blocks and the average cost of survey from data of 39 municipalities. Obviously, meaningful cost information would have to be determined for each community using the tree density data, Dutch elm disease rate, and hourly cost data for that community.

To assist managers in estimating survey costs for their communities, we have prepared a nomogram (Fig. 3) from the information in Figures 1 and 2. For the initial survey of the season and subsequent surveys, the cost per tree can be found simply by placing a straight edge across the nomogram from the appropriate survey point to the appropriate point on the scale of trees per mile of street. The cost per tree appears under the line where it intersects the appropriate hourly cost scale. For the subsequent surveys, the cost per tree is shown for two levels of disease incidence. For example, using 57 trees per mile the line on the lower chart in Figure 3 intersects the 2 percent disease-incidence scale of the $50 per hour scaler at slightly above 20¢ per tree.

Figure 3.—Nomogram for determining the survey cost per tree. To use the nomogram: Draw a straight line between the appropriate survey point and the appropriate point on the number-of-trees-per-mile scale. The intersection of this line and the appropriate cost-per-hour scale gives the survey cost per tree.





Save-the-elms Evaluation

To justify the time and expense of additional surveys, an improvement in Dutch elm disease control must be shown. Evidence for such improvement was found by comparing the results of intensive sanitation with those of conventional sanitation (Barger 1977). Municipal disease-control performance described by Cannon and Worley (1976, Figs. 1 and 2) was used as a basis for evaluating this improvement (Figs. 4 and 5).

At the beginning of our study, the test community had a fair performance record, having held their losses to about 5 percent per year (Fig. 4). Using Barger's (1977) data, we plotted elm losses under both sanitation programs (Fig. 4). The intensive sanitation program was significantly better than the conventional method. Each year, under intensive sanitation, fewer elms were lost to the disease than in the areas where conventional sanitation was used.

The results of our two sanitation programs were superimposed on the records in Figure 5 that show the length of time in which save-the-elms goals can be achieved with different program performance levels. The superiority of intensive sanitation over the conventional practice is clear. The effect of intensive sanitation may be to begin to move from fair performance toward good performance.

Survey is the key to removing diseased elms and, as the evidence presented in Figures 4 and 5 shows, multiple surveys and prompt removal lead to lower incidence of Dutch elm disease.

Figure 4.—Number of trees expected to die each year under each of four control-program performance levels. Enlarged section illustrates the results of conventional and intensive sanitation programs superimposed on these performance levels.

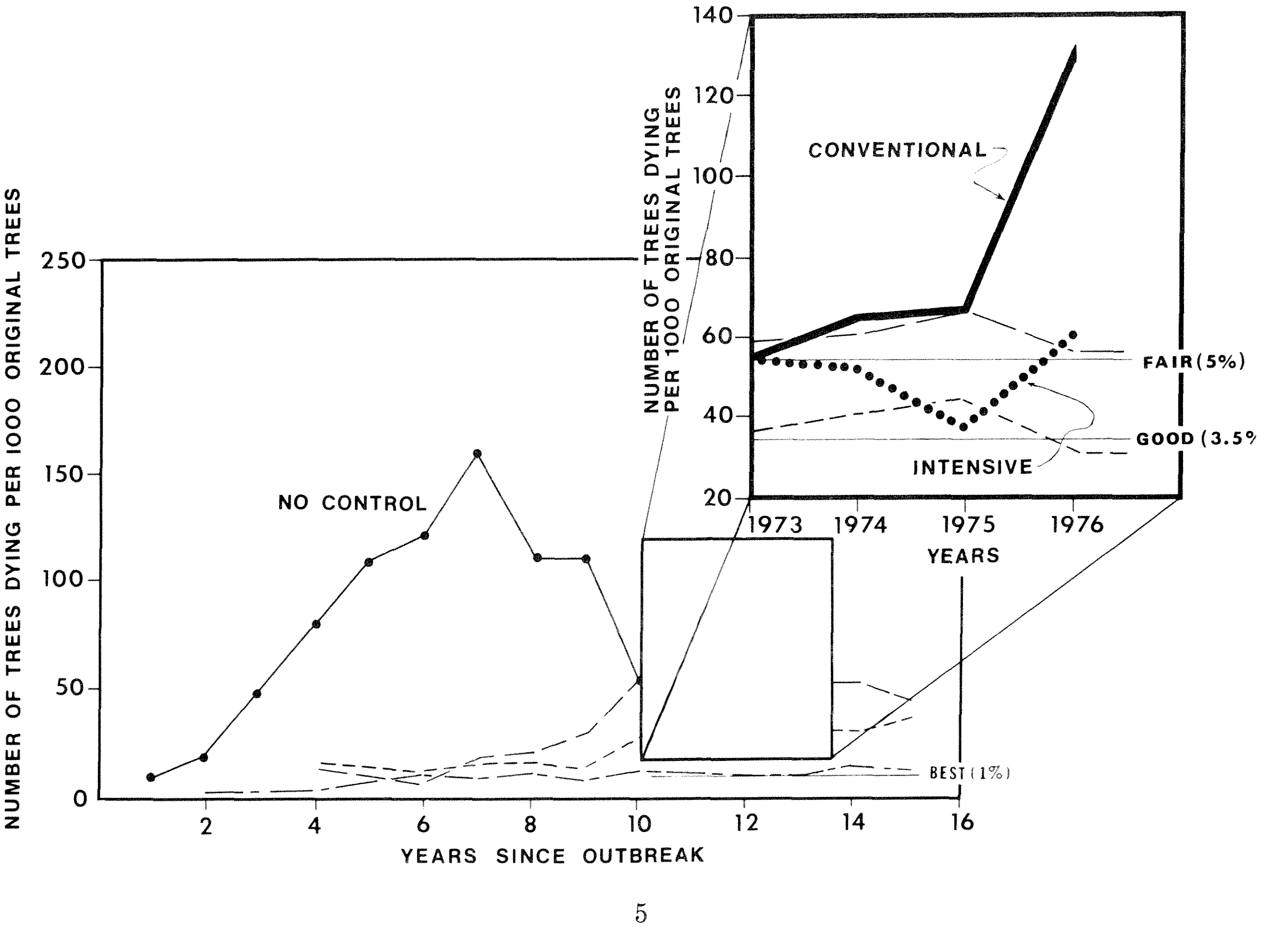
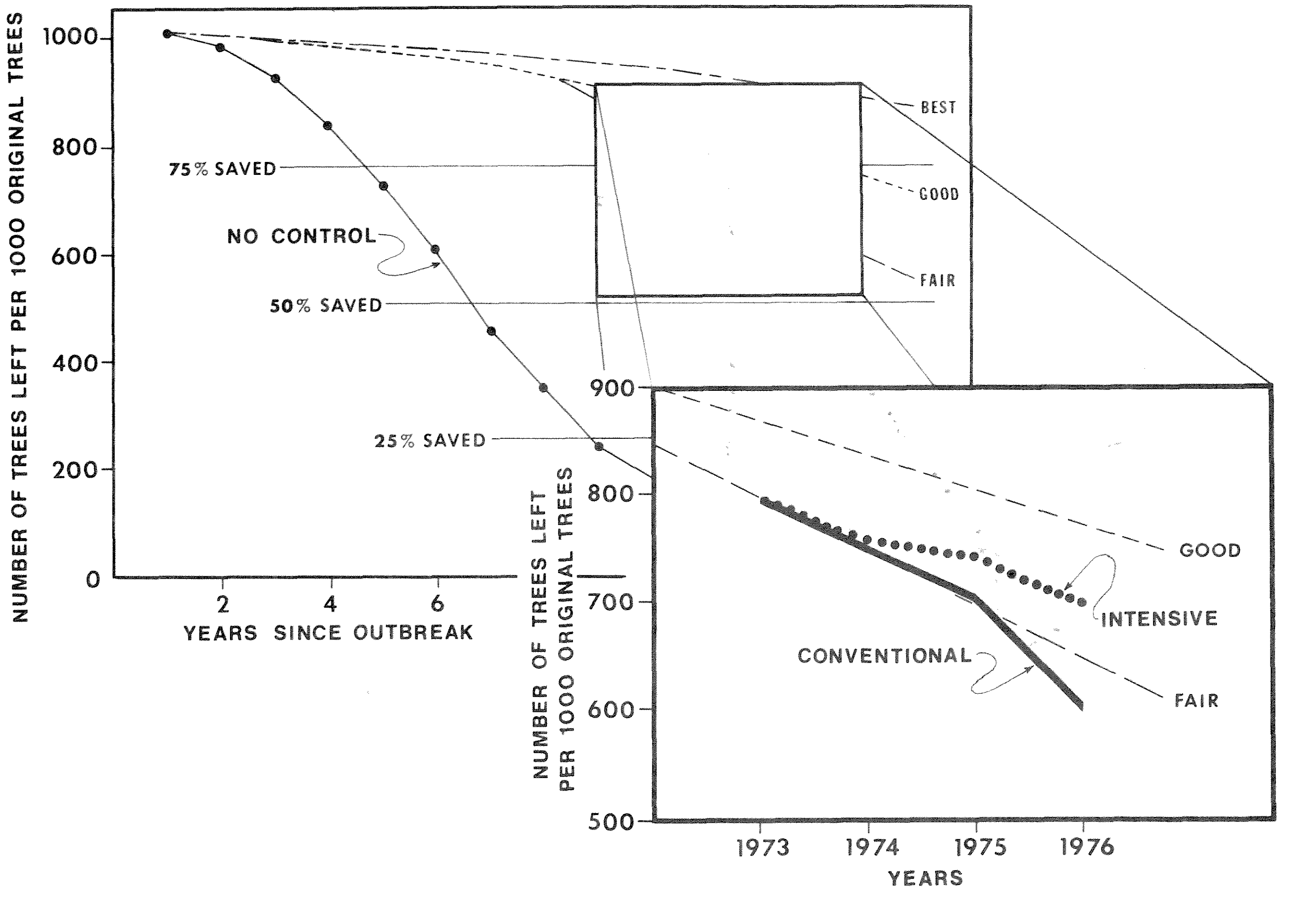


Figure 5.—Length of time in which save-the-elms goals can be achieved with different control-program performance levels. Enlarged section illustrates the results of conventional and intensive sanitation programs in terms of elms saved.



Financial Consequences

An example of how the costs of an intensive sanitation program might compare with those of a conventional program is given in Table 1. Our 3-year case history is presented to illustrate the budget for each sanitation program. We used the survey performance and costs developed earlier in this paper and the average tree-removal costs updated from the Cannon and Worley (1976) report. Tree-removal costs were increased by 20 percent for the intensive program, because crews must return again and again to the same areas to remove diseased trees.

After 3 years, the total cost of surveys for the intensive sanitation program was almost twice the survey cost for conventional sanitation. The tree removal costs, however, were less than 3/4 of those in the conventional program. This reduction in tree-removal costs far outweighed the increase in survey cost. The total amount saved by following the intensive program was 25 percent of the cost of the conventional program.

Comparison of the yearly costs revealed a small dollar saving for the first year. This saving grew rapidly until, by the end of the third year, the cost of intensive sanitation was only 60 percent of the cost of conventional sanitation.

Table 1.—Economic comparison of intensive versus conventional sanitation, based on a 3-year study, by 1,000-tree units

Item	Elms[a]		Dollar cost[b]			Dollar savings	Percent savings
	Beginning of season	Diseased removed	Survey	Removal	Total		
Intensive sanitation[c]							
Year 1	1,000	51	599	12,291	12,890	93	1
2	949	37	571	8,917	9,488	2,872	23
3	912	55	544	13,255	13,799	8,994	39
Total		143	1,714	34,463	36,177	11,959	25
Conventional sanitation[d]							
Year 1	1,000	63	320	12,663	12,983		
2	937	60	300	12,060	12,360		
3	877	112	281	22,512	22,793		
Total		235	901	47,235	48,136		

[a] Elm loss data from Barger (1977).
[b] Based on March 1977 dollars.
[c] Surveys made in mid-June, when 61% of the total diseased elms were identified; mid-July, 32%; late August, 7%. Survey cost set at $40 per hour. First survey at 32¢ per tree, subsequent two surveys at 1% disease rate at 14.5¢ per tree each survey. Cost of intensive tree removal set at $241 (cost of conventional removal plus 20% for extra effort required).
[d] Costs based on data from Cannon and Worley (1976); one survey at 32¢ per tree, and conventional removal during dormant season at $201 per tree.

Even More Surveys?

Our 3-year case history shows savings of both elms and money from following an intensive sanitation program. It may be possible to reduce the incidence of Dutch elm disease even further by increasing the number of surveys made during each season, provided that each survey is followed by prompt removal of diseased elms.

If the number of surveys per season were increased from three to four, if more diseased elms were found, and if prompt removal of these elms reduced the incidence of Dutch elm disease and thus the total cost of removing diseased trees, then the additional survey would have paid off. On the other hand, if four surveys during the summer revealed no more diseased elms than three surveys, then the fourth survey would contribute nothing. Since the cost of removing diseased elms now averages about $240 each in the intensive sanitation program, the cost of an additional survey might be justified if only one more elm per thousand were saved.

What would the picture be if we could lower the incidence of Dutch elm disease by adding another survey to our intensive sanitation program? We selected the most severe set of circumstances from our data: a sparse elm population (24 trees/mile) with 2 percent diseased so that the survey would proceed at a rate of about 160 trees per hour.

A scenario based on the above circumstances, patterned after the 3-year case history of intensive sanitation (Table 1), showed that if two additional trees per thousand could be saved each year, then an additional saving of 2 percent could be achieved. These savings would rise to 6 percent if four additional trees per thousand per year could be saved. The method for deciding whether another survey is warranted is presented in the Appendix.

Summary and Discussion

Surveys to detect Dutch elm disease are basic to any type of control program: early detection of the disease is essential to its effective control. When early detection was coupled with prompt removal of diseased elms, as in Barger's (1977) intensive sanitation program, then significant improvement in control was achieved.

A control effort that can reduce the number of trees that have to be removed without costing more than removing those trees will fit into a municipal budget without requiring additional annual funds. In our case the improved control program saved money as well as elms. This reinforces our view that frequent and thorough surveys are a worthwhile investment.

At present, diseased elms in most communities are detected by ground survey. Crews rely on visual identification of foliar symptoms of the disease. Although this method has been considered expensive in time, personnel, and transportation, our results show that it is well worth the cost.

We have used a fiscal perspective in this paper to assess the impact of survey and tree-removal costs on the municipal budget. It is important to note that by taking this viewpoint we have left out significant portions of the Dutch elm disease picture. We have not discussed the value of elm trees alive and well in city neighborhoods—a value that greatly overshadows the costs of surveys and tree removal. From the broader point of view of the total community, the physical, biological, and social benefits of saving trees are much greater than the monetary savings we have indicated.

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Appendix

How to Decide About Another Survey

The point at which the cost of added surveys balances the cost of removing trees depends on the number of trees that could be saved by the additional surveys. The break-even point for a 1,000-tree unit is easily computed, given the operating cost per hour and the number of hours required to survey 1,000 trees, or the survey cost per tree (determined from the nomogram in Fig. 4). Thus, since the

cost of another survey = *(survey cost per tree* x *1,000)*

or

= *(cost per hour)* x *(hours to survey 1,000 trees)*,

then the

$$\textit{(number of trees per 1,000 that have to be saved to break even)} = \frac{\textit{cost of another survey}}{\textit{cost of removing one tree.}}$$

For example, using our data for the highest-cost late-season survey, we find the

survey cost per tree = 30¢
survey cost per hour = $48
hours to survey 1,000 trees = 6.25

so that the *cost of another survey* = (30¢ per tree) x 1,000 = $300

or

($48 per hour) x (6.25 hours per 1,000 trees) = $300

Then dividing the *cost of another survey* by the *cost of removing one tree*, we find that

$$\frac{\text{\$300 survey cost}}{\text{\$240 to remove one tree}} = \text{1.25 trees need to be saved per 1,000 trees to break even.}$$

If you expect that an added survey and prompt removal will save 1.25 or more trees per thousand, then do the survey.

Suppose there are fewer than a thousand trees in a unit, say 800; 800 = 0.8 thousand trees and you need to save at least 0.8 x 1.25 = 1 tree to break even on the added survey. On the other hand, if you have 3,200 elm trees (3.2 thousands), then you need to save 3.2 x 1.25 = 4 trees or more to justify the expense of the added survey. If more trees than these could be saved, so much the better.

Actually, in choosing between three or four or more surveys a year as part of an intensive sanitation program, it is not necessary to save the "break even" number of trees each and every year; you only have to save that number on the average. If the number of trees that you could expect to save in an ordinary year was marginal, than an additional survey may be thought of as insurance policy against the exceptional year.

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