AN INTEGRATED DUTCH ELM DISEASE CONTROL PROGRAM FOR SAULT STE. MARIE: PART II

A Demonstration of Tree Pest Management in an Urban Environment:
A Cooperative Study Pursued by the City of Sault Ste. Marie, Ontario
and the Great Lakes Forest Research Centre, Canadian Forestry Service

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GREAT LAKES FOREST RESEARCH CENTRE

SAULT STE. MARIE, ONTARIO

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FOREWORD

This report is the second in a series outlining a joint venture by the Corporation of the City of Sault Ste. Marie, Ontario and the Canadian Forestry Service, Environmental Management Service, Environment Canada, to demonstrate and evaluate the extent of Dutch elm disease control possible when all appropriate control methods are put into practice in an integrated program.

After the second year, it is clear that there is a downward trend in DED incidence in Sault Ste. Marie, probably as a direct result of the program. However, the program will continue for an additional 2 years to bring DED fully under control.

To date the joint venture has been beneficial to both organizations: the city of Sault Ste. Marie has experienced a decline in DED incidence and the Great Lakes Forest Research Centre has been given a valuable opportunity to extend its field activities and implement its research findings.

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ABSTRACT

This report describes the second-year progress in an integrated Dutch elm disease program conducted as a joint effort by the city of Sault Ste. Marie and the Great Lakes Forest Research Centre. The program is an attempt to demonstrate the extent of control possible when all appropriate control methods are put into practice in an integrated manner. The second year's effort has resulted in a decline in Dutch elm disease incidence within the control boundaries.

RÉSUMÉ

Ce rapport décrit les progrès réalisés après la deuxième année de fonctionnement d'un programme de lutte contre la maladie hollandaise de l'Orme, entrepris conjointement par la ville de Sault-Sainte-Marie et le Centre de recherche forestière des Grands Lacs. Le programme vise à démontrer jusqu'à quel point il est possible d'exercer la répression lorsque toutes les méthodes de répression sont intégrées. Les efforts de la deuxième année ont effectué un declin de l'incidence de la maladie dans les limites de la zone expérimentale.

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INTRODUCTION

Dutch elm disease (DED) is caused by a fungus, *Ceratocystis ulmi* (Buism.) C. Moreau, which spreads through the vascular system of elm (*Ulmus* sp.). The disease is transmitted in North America by two species of bark beetles, the smaller European elm bark beetle, *Scolytus multistriatus* (Marsh.), and the native elm bark beetle, *Hylurgopinus rufipes* (Eichh.). Trees can also be infected by root grafts between diseased and healthy trees. In Europe and England, where different elm species are involved, infection through root grafts is more prevalent, and other species of bark beetle act as vectors as well as *S. multistriatus*. All North American elm species are susceptible to the disease.

The bark beetles breed in the bark of dead and dying elms. If the trees have been killed by DED or colonized by beetles carrying spores of *C. ulmi*, the emerging adult beetles may have spores of the fungus adhering to their bodies. Before eggs are laid in dying trees to start a new brood, part of the beetle population flies to healthy elms and feeds on the inner bark of twigs and branches. If the beetles penetrate to woody tissue, spores may be introduced into the water-conducting system of the tree, and a new case of DED will develop.

The disease was first recorded in North America in the United States in 1930 and was introduced into Canada in 1944. Devastation in the United States has been heaviest in the eastern and midwestern states, but DED now occurs in many of the western states as well. In Canada, elms in Nova Scotia, New Brunswick, Quebec, Ontario and Manitoba have been killed.

Losses have been tremendous. It is estimated that there were about 77 million elms in incorporated areas in the United States prior to 1930 and that DED has since killed 56% of these. It is also estimated that Quebec lost approximately 4,300,000 elms from 1940 to 1960. In many communities of Ontario, elm constitutes 50-80% of publicly owned trees, and in southwestern Ontario in particular, many communities have lost nearly all their elms. In a number of areas the trees have virtually disappeared from the rural landscape as well.

Several factors are involved in the disease: the pathogen, the insect vectors, the tree, and the environment of the tree. Attempts to eradicate the disease completely from an area have never been successful. However, control action against each of the factors involved can, in total, result in control of DED with few adverse environmental consequences. The disease incidence can be reduced to an endemic level from its present epidemic level.

The public has become more emotionally aroused about elms than about almost any other species of tree. For this reason alone abandonment of all attempts to control the disease would be unacceptable. At a more practical level, elm is one of the best species for planting in an urban environment where the stresses on any tree are very great. Elms provide a source of good-quality wood, and urban trees tended carefully throughout their period of usefulness as shade trees could provide high-quality veneer and lumber. At present the trees are merely destroyed. The increasing shortage of wood fibre also points toward the need to utilize, not waste, this species.

There have been many attempts to control DED by sanitation, by beetle control with insecticides, by application of various fungicides to the trees, by fertilization, etc. Recent advances in chemotherapeutic treatments by injecting newly developed fungicides into trees show promise for treating high-value trees. Research on the insect vectors has provided new insight into methods of monitoring and reducing beetle populations.

As yet, no community has mounted a concerted attack on DED using all the techniques currently available. Since many of the new techniques arose from research carried out at the Great Lakes Forest Research Centre (GLFRC) and since Sault Ste. Marie's Community Services Board (CSB) had an active DED control program for 8 years, the two organizations agreed in 1976 to pool resources in a demonstration of the kind of DED control possible when all appropriate control methods are put into practice in an integrated program.

The program was envisaged as both a corrective effort to bring DED incidence in the city under control as rapidly as possible, and as a vehicle for further research in recently developed control methods. Provision was made for future incorporation of new techniques and knowledge as these become available. Since the program will require several years to show definite results, it was planned to issue a short series of progress reports, of which this is the second, to make the knowledge gained in Sault Ste. Marie available to other communities in Canada and the United States where DED is a problem.

The members of the working group involved in the planning and operation of Sault Ste. Marie's integrated DED control program are as follows:

<u>Community Services Board, City of Sault Ste. Marie</u>

A. C. Cairncross, Director, Parks Division
L. G. Jago, Forestry and Horticulture Supervisor
L. R. Euale, Foreman, Forestry and Horticulture

<u>Great Lakes Forest Research Centre</u>

C. R. Sullivan, Program Manager
E. S. Kondo, Forest Pathologist
L. M. Gardiner, Forest Entomologist
G. D. Huntley, Forestry Officer

Questions, comments and suggestions with respect to the operation of the program are welcomed from agencies and individuals in the Sault Ste. Marie area and elsewhere. These should be directed to the individuals involved in the integrated control program. The addresses of the two participating agencies are as follows:

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Canadian Forestry Service
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SUMMARY OF 1976 RECOMMENDATIONS

The following recommendations resulted directly from the 1976 effort in initiating the Integrated DED Control Program. These recommendations were made for consideration in 1977 and subsequent years; most were implemented in 1977 wherever it was feasible.

(1) The program should be continued and enhanced in 1977.

(2) An attempt should be made to computerize data collected on individual trees, particularly the high-value trees.

(3) A study should be made of possible elm recruits to the high-value group, particularly trees now in the 3.5 to 10 cm class. Immediate consideration should be given to their care.

(4) An attempt should be made to interest service clubs in planting elms on suitable sites, particularly in low-hazard areas.

(5) An elm utilization study should again be considered as part of the program.

(6) A resurvey of the control area is desirable to establish the number of elms present. Mortality figures are still calculated using the 1968 count of 8,000 trees. Actual mortality, however, might not be so high if it were based on the present elm population. Elm is a prolific seed producer and there have undoubtedly been natural increases in elm numbers since 1968.

(7) All work should proceed on the assumption that a set of specifications will be drawn up for carrying out the various steps in DED control. Detailed written instructions are needed for injection procedures, mixing and application of sprays, treatment of diseased wood for use in constructing playground equipment, proper pruning, prevention of root grafts, sampling for DED detection, scouting for diseased trees, etc.

ACCOMPLISHMENTS IN 1977

ANALYSIS OF ELM LOSSES RESULTING FROM DUTCH ELM DISEASE IN 1976 AND 1977

Data on elm removals resulting from Dutch elm disease prior to and including 1975 were presented in Report O-X-268 (Fig. 2). The total percentage loss since 1969 was given for the 27 analysis areas. In this report, the data have been updated to include elm removals for 1976 and 1977. The percentage losses in 1976 and 1977 for each of the 27 analysis areas shown in Figure 1 of this report are given in Table 1. In Figure 1, the analysis areas show an increase in elm losses from 1976 to 1977 (cross hatched) or a decrease in elm losses from 1976 to 1977 (stippled). The unmarked analysis areas represent no change in elm losses from 1976 to 1977. Eleven of the areas show an increase in elm losses whereas 16 of the areas remain stable or show a decrease in elm losses.

There appears to be no correlation between the total number of elms within the various analysis areas and the corresponding rate of elm loss to Dutch elm disease. For instance areas 1, 3, 8 and 27 originally held 509, 438, 516 and 620 elms, respectively. However, areas 1 and 8 show an increase in elm losses since 1975 whereas areas 3 and 27 show a decrease. Similarly, analysis areas 2, 6, 14, 19, 20, 23 and 25 originally held 34, 67, 84, 67, 50 and 63 elms, respectively. However, areas 2, 6, 20 and 25 show an increase in elm losses since 1975 while areas 14, 19 and 23 show a decrease.

A pattern in elm losses appears to be developing within the control area of Sault Ste. Marie. In Figure 1 a general decrease in elm losses is evident in the western and northern parts of the control area while there seems to be an increase in elm losses to DED in the southeastern and north-central parts of the control area.

Area 13, located in the northwestern corner of the control area, contained 92 elms in 1968. During the period from 1968 to 1972 only four elms were lost to DED. However, analysis area 13 sustained heavy losses (88 elms) from 1973 to 1977. On the other hand, analysis area 24, located adjacent to area 13, had 361 elms originally, but has sustained only moderate losses (39%) from 1968 to 1977 inclusive.

It is very apparent that there are discrete areas within the overall DED control area with very different rates of elm loss to DED. These differences do not appear to be related solely to the elm population, although one would expect that elm population would greatly influence loss rates. Further investigation of these analysis areas are warranted to determine what factors make certain areas more susceptible to DED than others.

Bellevue Park lies entirely within analysis area 3. Originally, area 3 held 438 elms, of which 192 (43.8%) elms were found in Bellevue

Table 1. Percentage loss of elms in 1976 and 1977 in the analysis areas within the DED control boundary

Area no.	Original no. of elms	Total % loss 1968-1975	% loss 1976	% loss 1977	Change
1	509	28.1	10.0	12.6	+
2	34	17.6	3.0	23.5	+
3	438	30.6	12.8	11.4	−
4	134	45.5	8.2	0.8	−
5	316	28.8	20.3	28.8	+
6	67	59.7	4.5	6.0	+
7	224	35.3	18.8	25.9	+
8	516	17.3	3.3	17.2	+
9	112	33.9	15.2	13.4	−
10	171	39.2	19.3	18.7	−
11	385	10.1	2.6	8.3	+
12	132	38.8	16.7	7.6	−
13	92	64.1	27.2	8.7[a]	−
14	84	10.7	15.5	9.5	−
15	88	10.2	12.5	12.5	0
16	310	34.2	18.4	35.8	+
17	186	21.0	15.1	15.1	0
18	157	32.5	19.7	19.2	−
19	67	17.9	10.4	0.0	−
20	61	26.3	6.6	8.2	+
21	100	35.0	24.0	19.0	−
22	174	26.4	15.5	14.4	−
23	50	24.0	16.0	14.0	−
24	361	13.9	6.6	18.3	+
25	63	25.2	11.1	15.9	+
26	100	21.0	16.0	2.0	−
27	620	22.2	16.9	12.9	−

[a]Area 13 lost all original elms to DED in 1977.

Park. The elms in Bellevue Park have been under intensive management since 1974 when a drastic increase in elm loss occurred. Table 2 presents a summary of elm losses in the park since 1968 together with the Lignasan-BLP injection data since the initiation of the injection program. It is apparent from the data presented that analysis area 3 exhibits a decrease in elm losses in 1977 mainly because of the low rate of elm loss (8.9%) in Bellevue Park, whereas the loss rate in this area outside the park is 13.4%. Twenty-one of the remaining 107 elms have been under

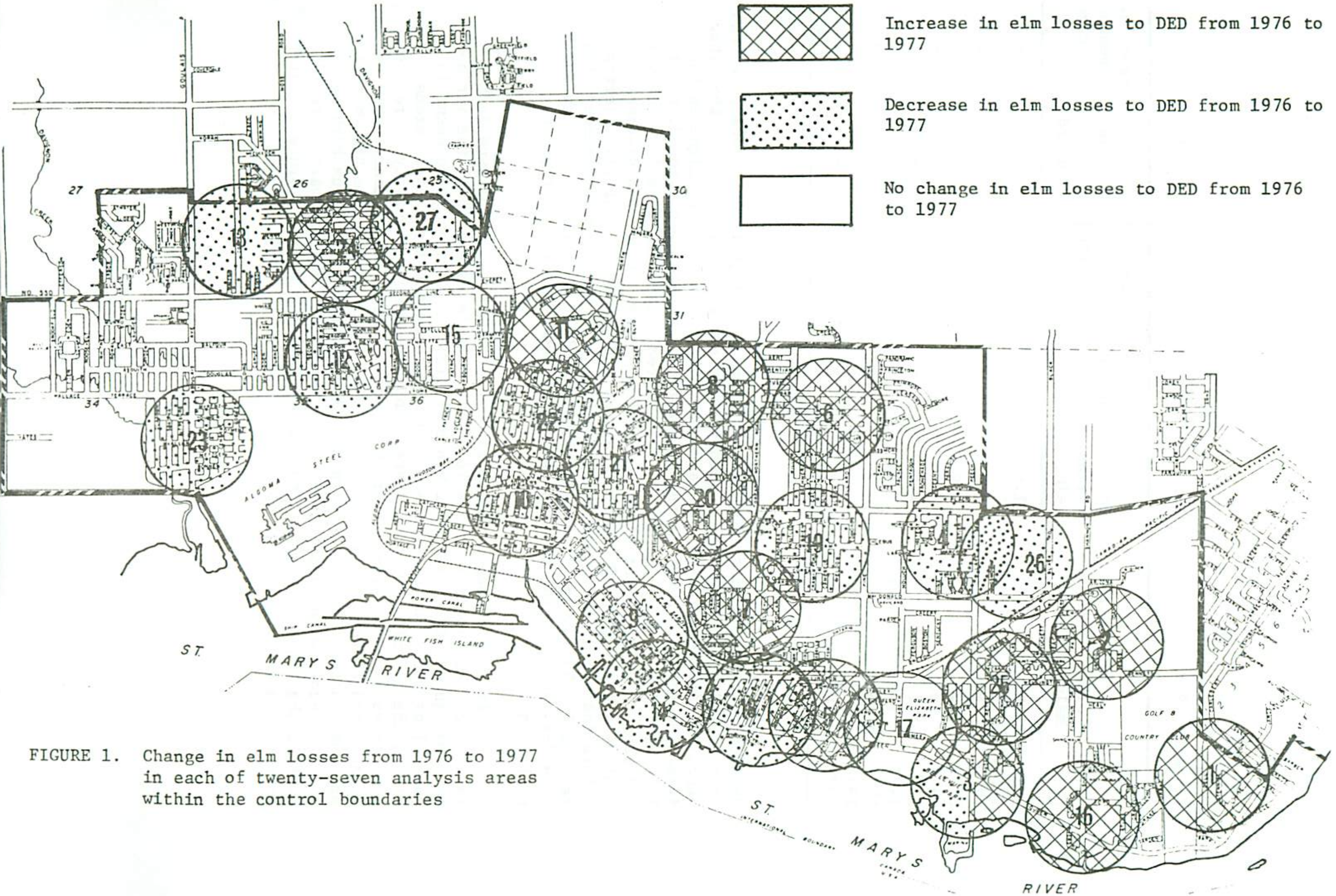


FIGURE 1. Change in elm losses from 1976 to 1977 in each of twenty-seven analysis areas within the control boundaries

Table 2. Summary of elm losses to DED in Bellevue Park, 1968-1971

Year	No. of elms remaining	No. of elms removed	% loss of original elms	Healthy elms injected	Losses of healthy injected elms	Diseased elms injected	Losses of diseased injected elms
1968	192	3	1.6	--	-	-	-
1969	189	2	1.0	--	-	-	-
1970	187	2	1.0	--	-	-	-
1971	185	5	2.6	--	-	-	-
1972	180	7	3.6	--	-	-	-
1973	173	3	1.6	--	-	-	-
1974	170	14	7.3	--	-	-	-
1975	156	26	13.5	14	0	4	0
1976	130	23	12.0	21	0	7	2
1978	107	17	8.9	21	0	7	5

chemical protection since 1976 with Lignasan-BLP injections. None have been lost to DED while the elm has been under chemical protection. On the other hand, 14 diseased elms in the park have been treated by the Lignasan-BLP injection method. Seven of the 14 treated elms have been removed, two in 1976 and five in 1977. Three of the treated elms which were lost in 1977 had been under treatment since 1975. Two of these three had disease indices greater than 50 before treatment and one was improperly injected (flare instead of root injection). Bioassay of two treated diseased elms removed in 1976 showed inadequate Lignasan-BLP distribution. No explanation for the remaining two losses in 1977 was evident from the data collected.

Figure 2 presents a comparison of elm losses in Bellevue Park and in the adjacent analysis areas 16 and 17. It is evident that the intensive management in Bellevue Park has resulted in a great improvement in control of DED. Further, it would appear that relatively small areas within the overall DED control area can be managed intensively to reduce elm losses substantially. Therefore, special areas could conceivably be established wherein elm loss would be even lower than in the DED control area as a whole. Figure 3 shows elm distribution in Bellevue Park as of 1977, together with locations of high-value elms, and removals since 1968. Most of the high-value elms within the park are chemically protected with yearly Lignasan-BLP injections.

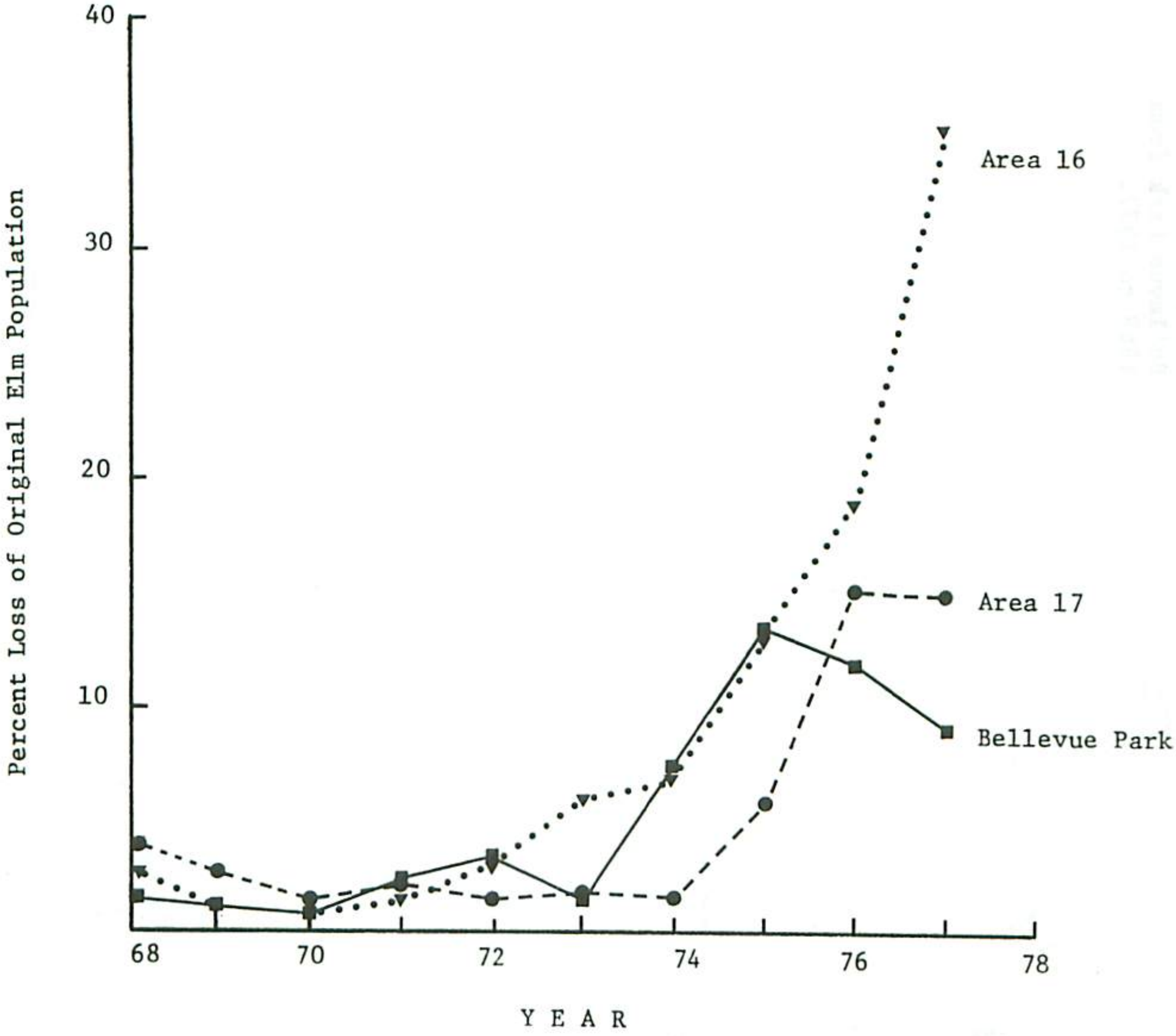


FIGURE 2. Comparison of elm loss in Bellevue Park and adjacent analysis areas

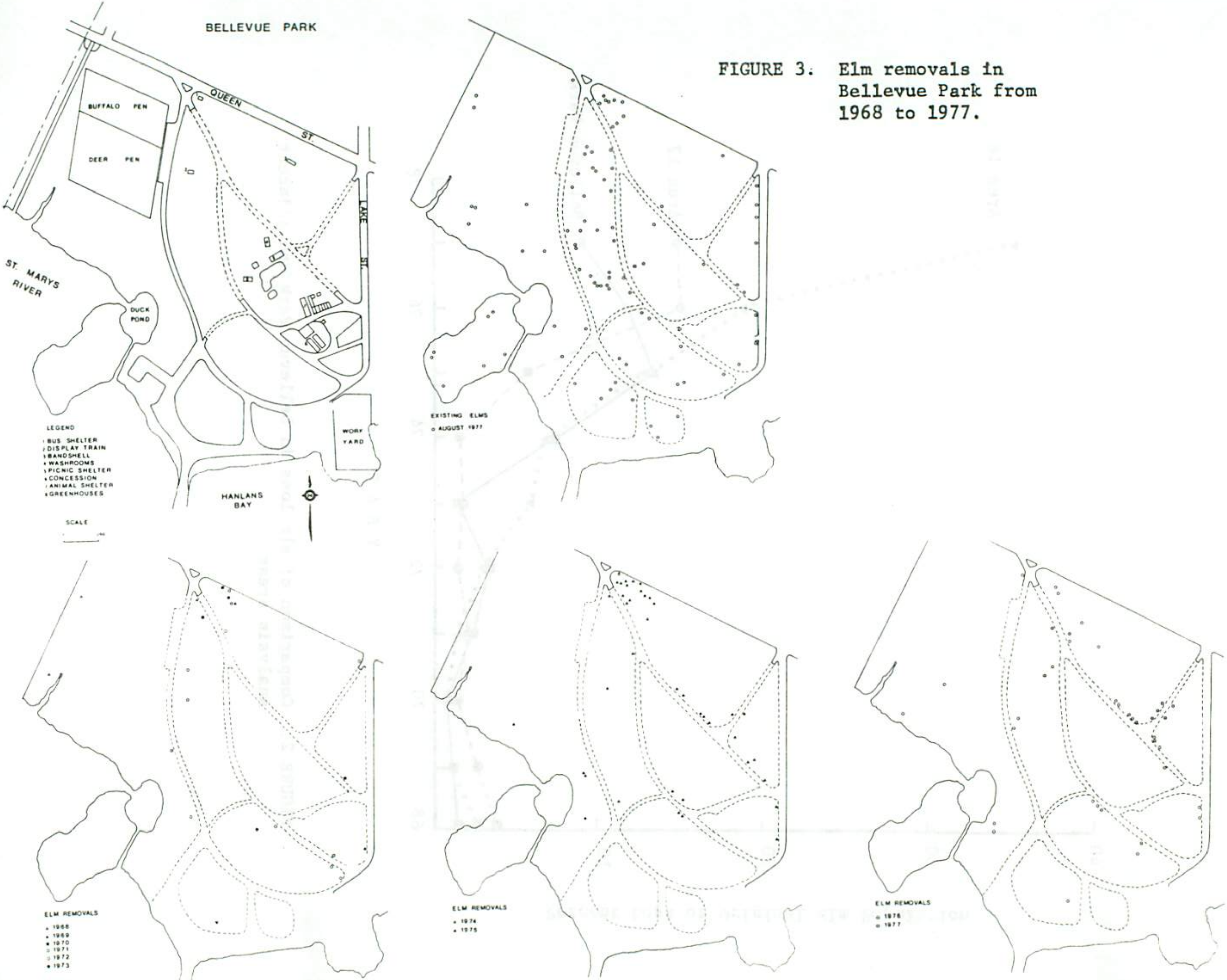


FIGURE 3. Elm removals in Bellevue Park from 1968 to 1977.

SELECTION OF HIGH-VALUE ELMS

The criteria for the selection of high-value elms remained the same as originally designed in 1976. While the details of these selection criteria are outlined in the 1976 report (Report O-X-268) the four basic factors considered are distribution and ownership, condition of tree, historical value, and location, i.e., accessibility for treatment. Table 3 indicates the number and general location of high-value elms that were selected both in 1976 and in 1977. The location of the high-value elm monitoring sections is shown in Figure 4. While 16 trees were

Table 3. Numbers and distribution of high-value elms selected and removed within the city of Sault Ste. Marie Dutch elm disease control area

High-value elm monitoring sections within control areas	Number of high-value elms selected		Number of high-value elms removed		Number of high-value elms, as of June 1, 1978
	1976	1977	1976-77	1977-78	
A	58	15	1	7	65
B	48	—	8	6	34
C	22	1	1	1	21
D	9	--	1	-	8
E	21	--	2	2	17
F	---	--	-	-	---
Total	158	16	13	16	145

added to the 158 originally selected in 1976, a total of 29 trees have been removed in the past two years. Consequently, at the beginning of the 1978 growing season there were 145 selected high-value elms distributed throughout the city of Sault Ste. Marie control area. Of the 29 high-value elms removed during this two-year period, only six had received injection treatment. One elm was removed because of road widening. In addition, of all the high-value elms selected but not treated, and subsequently removed, six were known to be diseased at the time of selection. The occurrence and rate of progression of the disease in infected elms exceeded the initial capacity of the city treatment crews. Therefore, it would appear that during the initial two-year period of the integrated DED program, more high-value elms were selected than could be readily subjected to prophylaxis or therapeutic treatment. However, the initial selection of 158 high-value elms in 1976 was necessary to establish a

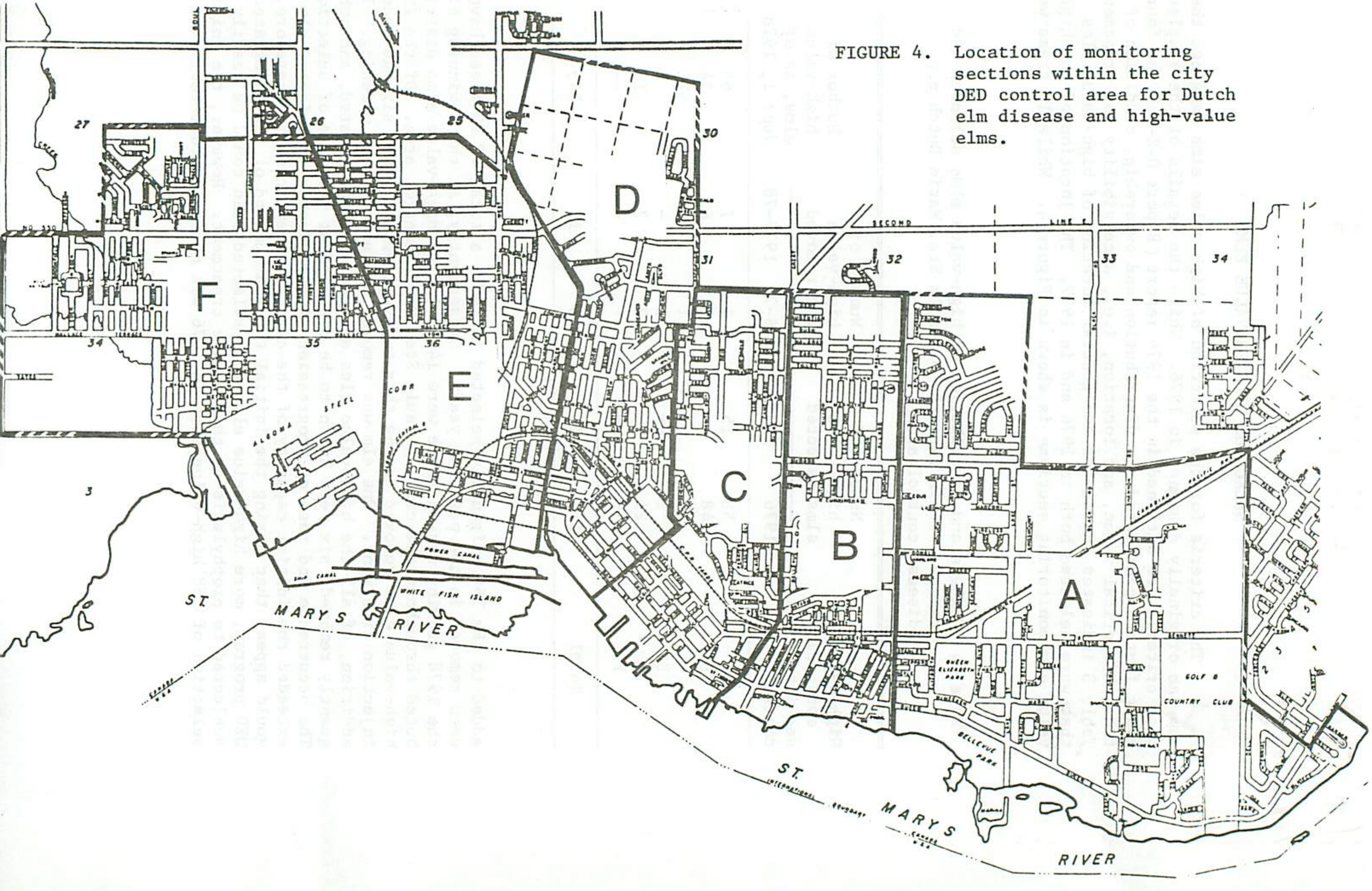


FIGURE 4. Location of monitoring sections within the city DED control area for Dutch elm disease and high-value elms.

nucleus of trees considered worthy of preservation. As the number of high-value elms subjected to chemical protection increases each year, the treatment crews will become better able to respond quickly to notifications that high-value elms have become infected. Therefore, a subsequent increase in treatment capacity should allow an increase in the total number of high-value elms that can be selected. In time it is hoped that the program can be extended to include a total of approximately 300 high-value elms within the city's DED control area.

BEETLE MONITORING

Native Elm Bark Beetle

Since 1973, beetle activity has been monitored at selected sites throughout the control area with sticky traps mounted in the crowns of healthy elms. Periodic counts of trapped beetles give a measure of their populations, and continued monitoring gives an excellent picture of population fluctuations over the years.

Figure 5 shows the results of 5 years' trapping in Sault Ste. Marie, grouped by trap location and spring, summer and fall flights. These flights and their significance were explained in last year's report (Report O-X-268). It was also pointed out that the buildup of activity in 1974-1975 and the accompanying, increased losses of elms to DED, are attributable to large populations of beetles bred in dying, wild elms around the city. An encouraging downward trend in activity was noted in 1976 and hope was expressed that it would continue because of reduction in breeding material outside the control area and more efficient sanitation inside. The lesser activity in 1976 was accompanied by a reduction of DED incidence in 1977.

It is gratifying to report that the downward trend begun in 1976 did continue in 1977 (Fig. 5). All across the control area distinctly fewer beetles were trapped in the fall. This means that numbers of beetles entering the area from outside to overwinter were much reduced, and our research results indicate that this should substantially diminish the incidence of DED in 1978.

European Elm Bark Beetle

Although this species has never gained a foothold in this area, a few specimens may be captured each year in Sault Ste. Marie. A few were found on the sticky traps used to monitor native beetle activity, and 24 were attracted to three pheromone traps baited with 'Multilure' on the grounds of the Great Lakes Forest Research Centre.

It is not known how these small numbers persist in appearing; six years of research have failed to turn up any instances of local

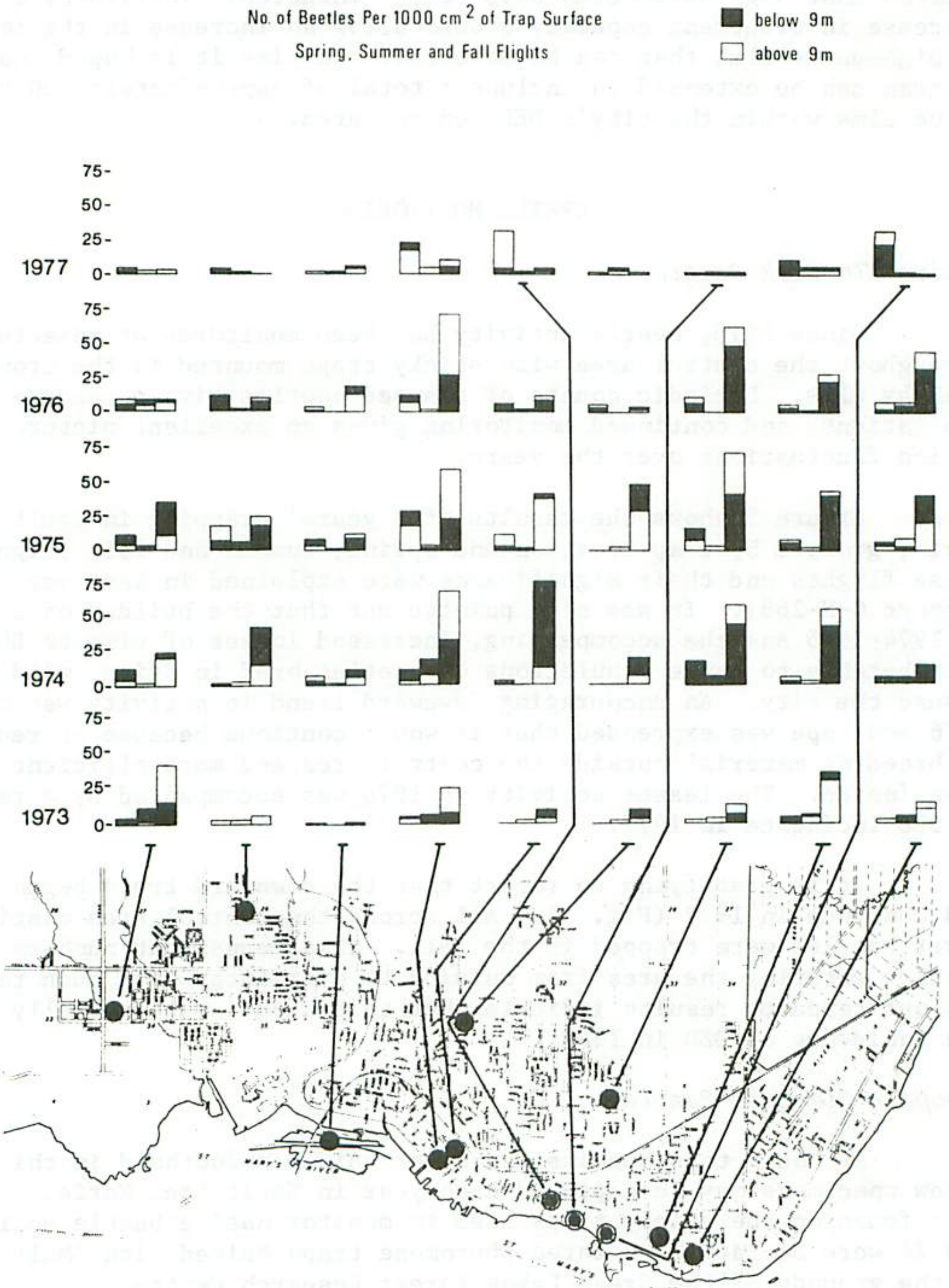


Figure 5. Native Elm Bark Beetle Occurrence in Elm Crowns

breeding by this beetle. Indeed, as long as proper sanitation is practised, it is difficult to see how it could become significant in this area.

Monitoring beetle activity in elm crowns by use of sticky traps.

VECTOR CONTROL

Control of Overwintering Adults

As in 1976, all elm trees over 5 cm DBH in the test area bounded by Shannon Road, Wellington Street, Pine Street and the St. Mary's River were treated. Chlorpyrifos was applied at a concentration of 0.5% a.i. to the lower 2 m of the trunks by means of a Holder Supra 40 backpack mistblower in the latter half of August. Spray was applied in early morning when wind was minimal until the bark was wet. Again, residents in the area cooperated fully.

Efficacy of treatment was again assessed by counting boring dust piles in bark fissures in a 25 cm basal band on trees inside and outside the test area. The results were as follows:

Treatment	No. of trees	Boring dust piles/m^2	Control (%)
Outside area	16	109.6	--
Inside area	20	0.8	99

Control of Branch Feeding

Since, in Canada, most cases of Dutch elm disease arise through infection in feeding niches caused by native elm bark beetles in elm branches, prevention of such feeding is desirable in controlling the disease. Experience in 1975 and 1976 with chlorpyrifos in preventing beetle penetration into trunk bark suggested that this chemical might be effective in reducing branch feeding.

Under experimental permit, whole-tree treatment with chlorpyrifos (Dow Chemical Company's Dursban 2E) was carried out in a park at Selkirk, Manitoba and in the Cathedral-Legislature area of Fredericton, New Brunswick. At Selkirk, 40 trees were sprayed on 29 April with 0.5% a.i. and on 12 May another 50 trees were treated with a 1.0% spray, both being applied with a hydraulic sprayer capable of producing a pressure of 500 p.s.i. In Fredericton, 54 trees were treated with 1.0% chlorpyrifos applied with a mistblower.

Sample branches were taken from treated trees in May and tested for chemical activity by a bioassay technique developed previously.

In the bioassay technique, individual beetles are confined on the bark of a 25 cm section of sample branch, in cages made with 7-mm brass tubing. A 25 mm length of tubing is used and one end is closed with fine brass screen soldered to the tubing. To confine the beetle on the branch sample a circle is cut in the bark with a 7 mm (approx.) cork borer and the cage containing the beetle is forced into the cut where it remains held by friction. Three beetles are thus confined on each branch sample. The sample is then held in an incubator at 26°C and 90% R.H. for 6 days.

Assessment of chemical effect may be measured in several ways at the end of the period: beetle living or dead, beetle penetration into phloem, or beetle penetration through the phloem to *score* the surface of the xylem.

The last criterion is the one generally used in these tests. It is a meaningful standard in that a beetle, contaminated with the Dutch elm disease fungal spores, must penetrate to the xylem of the tree where the spore(s) must germinate in order to produce a new infection.

The results of the bioassay were as follows:

Treatment		N	Into phloem	Scored xylem	Alive	Control (%)[a]
Fredericton	1.0%	45	7	0	2	100
Untreated		45	33	19	35	
Selkirk	0.5%	60	6	3	4	89
Untreated		60	44	28	52	
	1.0%	60	22	2	12	92
Untreated		60	46	26	50	

[a]Measure of prevention of xylem scoring

The bioassay results indicate that chlorpyrifos applied to the crowns of living elms in the spring offers excellent protection against feeding by native elm bark beetles and particularly against penetration by the beetles to the xylem. This type of treatment should therefore be useful in giving maximum protection to high-value elm trees.

SAMPLING AND CULTURING FOR POSITIVE IDENTIFICATION OF DED

As in 1976, sampling and culturing of elms other than high-value elms for positive identification of DED within the control area boundaries were generally undertaken only in doubtful cases of disease symptom expression. All high-value elms exhibiting disease symptoms were immediately sampled and cultured in the laboratory for positive identification of *Ceratocystis ulmi*, so that appropriate control measures could be undertaken without delay. Usually, positive identification was made within 5 days of sampling. In all cases of negative results in culturing, an additional two attempts at sampling and culturing were made before the elm in question was considered healthy.

In 1977 sampling for disease began about June 7 when DED symptoms first became obvious. Usually, DED symptoms first become obvious in the third week of June in Sault Ste. Marie. The early disease expression in 1977 was probably due to the hot and dry weather conditions experienced in May and June in Sault Ste. Marie.

Table 4 presents a summary of the results of sampling and culturing. From a total of 60 suspect elms which were sampled and cultured for the presence of *Ceratocystis ulmi*, 32 were found to be positive. Seventeen of the submissions were from high-value elms and nine were found to be infected. The larger percentage of samples proving negative in August can probably be attributed to problems encountered by the scouting crews in

Table 4. 1977 summary of results of sampling and culturing for *C. ulmi*

Month or sample date	No. of elms sampled	Isolation of *C. ulmi* Positive	Negative
March	2	1	1
June	12	5	7
July	29	21	8
August	17	5	12
TOTALS	60	32	28
Sept. 28	1	1	0
Oct. 28	1	0	1
Nov. 29	1	1	0
Dec. 16	2	2	0
Dec. 21	1	1	0
Jan. 12	1	1	0
Jan. 24	2	2	0
Jan. 31	1	1	0
Feb. 3	1	1	0
Mar. 30	1	1	0
TOTALS	12	11	1

differentiating between early fall color and disease symptom expression.

It has been suggested that *C. ulmi* may be difficult to isolate from diseased elms during the winter. Since Sault Ste. Marie generally has winter temperatures as low as -25 to -30°C, an experiment was conducted to determine whether it is indeed more difficult to isolate *C. ulmi* from diseased elms in the winter. From September 28 to March 30 samples showing vascular discoloration were collected and cultured from elms known to be diseased which were being removed during the regular winter removal program. Only on one occasion in October was the fungus not isolated from the diseased samples. Generally, no more difficulty was encountered in isolating *C. ulmi* from samples collected in the winter than from samples collected in the summer months.

CHEMICAL INJECTIONS OF ELMS

All high-value elms were examined on a weekly basis from June 15 to September 1 and new cases of DED were promptly reported to the CSB

Forestry Department so that therapeutic injection and pruning could be undertaken with a minimum of delay. Scouting of high-value elms after September 1 was not undertaken since the injection areas were not available after this date. Generally, new infections in high-value elms were discovered, reported and confirmed for disease rapidly enough that very few were found that could not be injected. That is, the disease index (DI) at time of treatment was below 50. The only exceptions occurred in the late spring when the disease symptoms tended to spread throughout the elm crown at a very rapid rate. This period lasted from the time when DED symptoms were first expressed in the Sault Ste. Marie area until approximately 2 to 3 weeks later. During this short period in the late spring the disease index could jump from below 50 to above 100 in 1 or 2 days. Therefore, early in the injection season it is advisable to employ 15 as the upper disease index for approximately 3 weeks to determine which elms can be injected. If this rule of thumb is not employed, much time and money will be wasted since the DI could conceivably be well above 50 by the time the elm is fully prepared for injection.

A total of 101 elms were injected during 1977 (Table 5). Sixty-two high-value elms were treated prophylactically and 15 therapeutically. Twenty-four elms other than high-value elms were chemical injected. Most of these elms, although not of high value, were deemed important enough to warrant an attempt at therapy during slack periods in the injection program. This aspect of the program was well coordinated so as not to jeopardize the treatment of any high-value elm. In 1977, three high-value elms treated therapeutically were lost from a total of 15 diseased elms treated.

Chemotherapy is generally effective only when Lignasan-BLP is root-injected. Therefore, in 1977 most high-value elms that could not be root-injected were placed under chemical protection by root-flare injection with Lignasan-BLP. This precaution was taken as a result of experience in the 1976 injection program wherein a number of high-value elms became infected but could not be injected properly through the roots, because the roots were not readily accessible.

A single CSB Forestry tree-injection crew composed of a group leader and three forestry student assistants carried out all injections. The crew was supervised by the CSB Forestry foreman who is trained and certified by the Ontario Shade Tree Council in root and root-flare injection with Lignasan-BLP. Using a half-ton (.45 tonne) truck, equipped with a 900 L reservoir, an AC generator and other necessary equipment, the crew worked a 40-hour week for 13 weeks beginning June 6.

Table 6 presents a cost analysis for the injection program. Only 30% of the cost of some of the equipment was applied to the 1977 expenses since the equipment could be used for a number of years or for other work. As expected, the major cost was for labor ($8,632.00) which amounted to 59% of the total cost of $14,557.60. The cost of the chemical Lignasan-BLP, though high ($2,728.00 for 800 L), made up only 18% of the total cost.

Table 5. Summary of Lignasan-BLP injections, 1977

Zone	No. of elms injected				Total no. injected 1977	Elms reinjected from previous years	Losses of 1977 injected elms	Losses of elms injected in past years (not reinjected in 1977)
	High-value elms		Other elms					
	Therapy	Prophylaxis	Therapy	Prophylaxis				
A	6	25	5	5	41	21	2[a]	3
B	4	23	0	0	27	9	1[b]	0
C	2	7	8	5	22	19	0	0
D	1	3	0	0	4	1	0	0
E	2	4	1	0	7	6	0	0
TOTALS	15	62	14	10	101	56	3	3

[a]Both losses are high-value elms which had been therapeutically injected since 1975.

[b]Loss is a high-value elm, which was therapeutically injected although Disease Index was greater than 50 at time of injection.

Table 6. Cost analysis for injection

Materials and Supplies	Cost
800 litres Lignasan-BLP @ $3.41 per litre	$ 2,728.00
2 injection units with accessories $1,040.00 (Units useable for many years) 30% of cost	$ 312.00
1 plastic injection solution reservoir (909 litres capacity) (Reservoir useable for many years) 30% of cost	$ 60.00
1 portable AC generator (useable for many years) 30% of cost	$ 36.00
Miscellaneous costs	$ 200.00
TOTAL COST OF MATERIALS AND SUPPLIES	$ 3,336.00
Labor	**Cost**
Group leader - 13 man-weeks @ $5.80 per hour	$ 3,016.00
3 student assistant workers - 39 man-weeks @ $3.60 per hour	$ 5,616.00
Overhead - 30% of labor costs	$ 2,589.60
TOTAL LABOR COSTS	$11,221.60
TOTAL INJECTION COSTS FOR 1977 FOR 101 ELMS	$14,557.60

Cost of $144.13 per elm injected

Since 101 elms were injected, the average cost of treatment of a single elm was $144.13. Because of the research involvement in the program, this figure is relatively high when compared with those of other municipalities, where the average cost is only $90.00 per elm treated.

Community Services Board elm injection crew treating a high-value elm.

SCOUTING FOR DED

The importance of an efficient scouting system for diseased trees cannot be over-emphasized, since it forms the basis for a good sanitation program. Use of additional manpower to provide more intensive coverage in the control area throughout the scouting season paid off in 1976 with a more accurate disease count. Previously, general scouting was carried out by the Community Services Board using one and periodically two forestry students from late June to late August. This method was not completely effective because many areas were checked only once and diseased trees could be and were missed. In 1976 the integrated program staff provided assistance by dividing the area into sections for weekly scouting of high-value trees and other elms (Fig. 4). This system provided more reliable coverage especially in ravine and woodlot areas and was expanded in 1977 by having participants submit Treatment Action Forms (Appendix I) of other new DED sightings to the CSB to insure that follow-up action was undertaken as required. Full results of this method will be known by midsummer of 1978.

Details of scouting methods now applied are as follows: Depending on weather conditions and the timing of beetle flights the scouting is started from mid- to late June and completed in mid-September. Using a vehicle for general transportation, but walking were necessary, the chief scout covers each portion of the control area using quarter-section city cadastral maps which detail all properties, buildings, residences (including civic numbers) and streets. As diseased trees are located their trunks are marked at eye level with a red circular spot (approximately 10 cm in diameter) and then field mapped, and information such as date, location, height, DBH, map number and special remarks are recorded on a Survey Sheet (See Appendix II). The tree is also assigned a number which it retains until notifications are sent out. The work order for removal is made out and the tree is removed by the following spring according to a removal schedule (Appendix III).

A scout is trained to recognize disease signs, but when he is in doubt he marks the tree with a green circular spot (approximately 10 cm in diameter) at eye level for reinspection and/or branch sampling so that it can be cultured in the laboratory for positive identification of the disease. All pruning tools used must be disinfected so as not to contaminate other elms.

If completely dead trees are found during the scouting season a careful trunk inspection is carried out under the bark for elm bark beetles in either the larval or the adult stage or for emergent holes. Generally these trees are removed immediately. This procedure is carried out daily until the complete control area is covered. The season is finished in the tax office at city hall where the names and addresses of all property owners are obtained so that removal notifications can be forwarded.

The integrated elm staff augments this work by providing weekly coverage of a much larger area assigned to them. Their reports (See Appendix I) are submitted to the CSB scout for his final inspection and recording. Weekly meetings for all staff concerned provide the means for better communication and settling disputed sightings. Coverage is also improved since integrated staff are free to check one another's areas and report sightings.

SANITATION

The 1977 sanitation program cost the city $58,051.00. Work included removal, disease scouting, trimming and injection of other than high-value trees. The work breakdown is as follows:

(a) removals by city crews and contract - 1001 trees (from 1976 survey) (Table 7)

(b) trimming by city crews - 23 trees

(c) injection by city crews - 101 trees

Table 7. Elm disease program losses within control area[a] 1968-1977

Year	No. of removals[b]	Percentage loss
1968	146	1.8
1969	119	1.5
1970	91	1.1
1971	255	3.2
1972	380	4.7
1973	454	5.7
1974	389	4.9
1975	580	7.2
1976	1,001	12.5
1977	740	9.3
TOTAL	4,155	51.9

[a]Based on an estimated total of 8,000 elms within the control area. "Wild" elms generally small in diameter, and trees in uninhabited woodlots and ravines, not included.

[b]Includes removals on both private and municipal properties.

This brings the total 10-year cost for Dutch elm disease control from 1968 to 1977 inclusive to $243,251.00.

Infected trees must be removed in the Sault Ste. Marie area on or before April 15 of the scouting year to prevent beetles from spreading. Therefore, because of other work commitments and the advantages of removing trees when snow is on the ground and when excessive cold makes trimming work uncomfortable, our removal program generally runs from late November to mid-April. Only professionally trained tree climbers are employed for the removal work because of the hazards involved. This force is augmented with equipment operators who also assist with grounds duties and cleanup. The Parks Department's forestry section consists of one supervisor, one foreman, one crew leader/climber, three tree climbers and four equipment operators for winter removals. (Both supervisor and foreman are also in charge of the Horticulture Section.)

All wood is either chipped and re-used or hauled to the municipal dump for burial with other refuse. Some logs are kept and barked for park playground construction or sold for sawmilling. A portion of the removals, particularly woodlot area removals, are removed by local contractors under the tender system. Two types of tenders are used: one for semi-skilled timber operators, of which there are many in this area, and the other for professionally skilled arborists where piecemeal removal is required. Use of contractors for this type of work has many advantages and can frequently reduce removal costs if a municipality does not have an efficient work force or has other work commitments.

All trees must be cut as close to ground level as possible and the remaining bark on the stump is axed off to remove possible beetle breeding areas. Where it is not efficient to axe large stumps, the remaining bark is sprayed with a 12% solution of Methoxychlor and fuel oil.

Cleanup of all work sites is carried out to the degree that all limbs or branches which attract breeding beetles are removed; the property owner is expected to clean up the remainder.

Removal work is also carried out as required whenever beetle-infested trees are located before flight times in late summer. This can happen in wooded or ravine areas where infected trees can easily be missed by elm scouts in the previous year.

Removal costs per tree in 1977 were as follows:

Municipal trees by city forces	-	$162.00 per tree
Private trees by city forces (generally residential and requiring piecemeal removal)	-	$103.00 per tree
Private trees by contractors (generally woodlot trees)	-	$ 72.00 per tree

ELM PLANTING AND ESTABLISHMENT

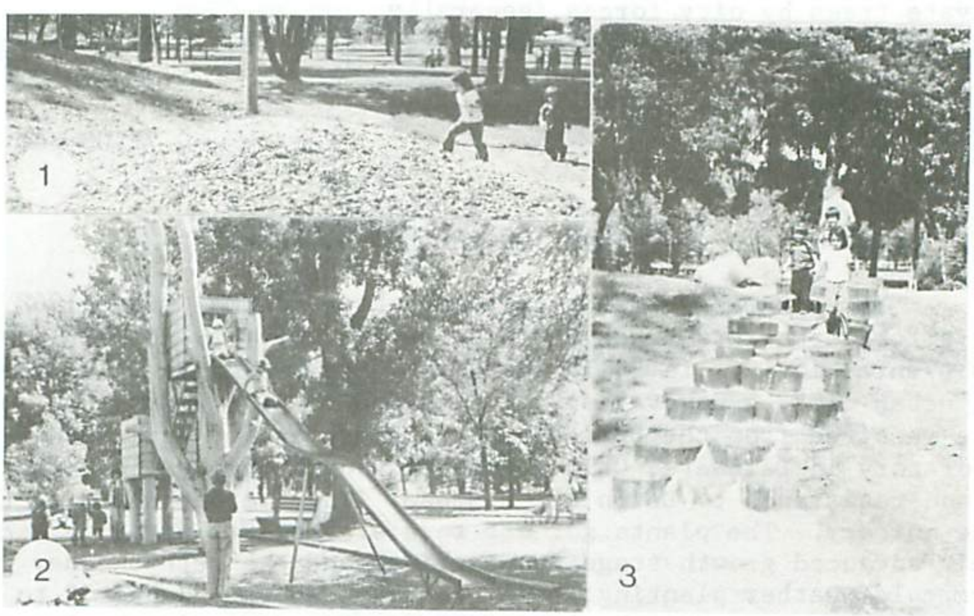
Elm plantings in the city have been minimal since 1968 because of the efforts put into Dutch elm disease control. As in 1976 another elm was planted in 1977 in Bellevue Park by the city. Ten first-year grafts of "urban elm", a new variety of Siberian elm (*Ulmus pumila*) rootstocks, were received from the United States Department of Agriculture research laboratory in Delaware, Ohio for testing of hardiness in Climate Zone 4B and resistance to Dutch elm disease. They were planted in the city tree nursery. The plants got off to a slow start, probably because of their advanced growth stage upon arrival and the setback they received from cold weather planting; however, they recovered, and 30 to 90 cm of new growth was observed by late summer. One tree died by September.

No action was taken on the recommendation made in the 1977 control program report to interest service clubs in planting elms in low-hazard areas of the city.

ELM WOOD UTILIZATION

Elm is a valuable wood species for lumber and veneer, and even for mulch when it is chipped. Wood-chip mulch is always in demand for municipal park and industrial plantings; utilization of removals for this purpose, however, has been limited. It may be economically feasible to market removals as this could provide revenue to municipalities to help defray costs of sanitation programs. To date, however, little has been done to develop a large-scale market or to overcome such problems as the presence of metal in trees. Although investigation of better utilization has been recommended as part of the integrated program, demands on time and human resources have prevented work in this area.

Since 1973 the city has utilized elm in many ways: It has authorized removal contractors to market logs if they reduce tender costs, or has instructed the contractors to save marketable wood, which the city then sells by tender to the highest bidder. Butt logs are not kept because metal which generally dulls or ruins mill saws can most often be found in the butt portion. Wood is usually milled and utilized locally and all marketing is under strict control until material is outside the sanitation control area. These methods utilize some wood; to date however, sale revenues have been limited because of lack of markets and handling costs.



Elm utilization:
1. Elm chip pile for use in mulching
2. Major portion of elm used as a support for a children's slide in Bellevue Park
3. Steps constructed of elm discs in Bellevue Park

Wood is also barked and stockpiled for park playground construction. Although handling costs are high the wood is excellent for this purpose because of its strength and rot resistance. Only limited amounts of wood can be utilized for this purpose, however.

Limbwood up to 15 cm in diameter is generally chipped during removal operations. The chips are piled and used for mulching of shrub beds and under playground equipment in place of sand. This reduces park maintenance labor. Elm chips, however, are stringy and are best topped or mixed with chips of other wood species. It has been noted that fresh chips have attracted bark beetles, and this suggests the possible need for obliterating the wood smell. This potential problem bears further investigation.

ELM POPULATION RESURVEY

One of the recommendations of the 1976 integrated program was a resurvey of the control area to establish the number of elms present. Yearly mortality figures (Table 7) are still calculated using the 1968 estimated count of 8,000 trees. Elm is a prolific seed producer and there has undoubtedly been a natural increase since 1968. A grant of $16,522.00 was provided by the Federal Young Canada Works program to employ five forestry students during the 1977 summer months for a total of 90 work weeks. Supervised and trained by the Community Services Board foreman, the students, mostly from the first and second year forestry technician course at the local Community College, walked and field mapped the entire control area. Briefly, their work program was as follows:

1. Initial interviews and hiring. Students with good marks in dendrology and some survey experience were chosen.

2. Briefing sessions on the city disease program and mapping. Quarter-section cadastral maps which detail all properties, buildings, streets, subdivisions, etc., were to be used. Working in pairs, each group was to survey a complete predetermined section and do on-the-spot mapping of all elm species over 5 cm DBH. Map information was to include: species, estimated height, exact DBH, whether on private or municipal property, and whether dead or alive. Trees with two or more trunks all touching each other at ground level were to be classed as clumps; all others were to be classed as singles. Questionable trees were to be classed by the forestry foreman and/or supervisor. In wooded areas or where large numbers of trees could cause confusion in mapping, areas were to be blocked off or marked with flagging tape, or the bases were to be marked with small spray paint markings.

The program started 18 May and was completed on its due date of 5 September. Students covered the greater portion of the approximately

36 km^2 area on foot after being dropped off each day by Community Services Board vehicles. All mapping was completed on time; however, analysis of the information by the students could not be finished before the end of the program and was therefore done by Department staff.

The 1977 resurvey for elms has shown the importance of periodic surveys. The amount of data collected was too large to handle by conventional filing systems, and retrieval of data is extremely cumbersome. Therefore a decision was made to conduct a second survey in 1978 with the purpose of computerizing the data collected, including all available past data collected by the CSB. Therefore, to avoid confusion, the final 1977 elm count will not be employed. The final count will be obtained from the 1978 survey and subsequent computer printout.

RECOMMENDATIONS

In the second year in which the integrated Dutch elm disease control program was in operation in Sault Ste. Marie, the incidence of elm loss attributable to the disease decreased over that of the previous year. It would appear that the efforts of the program were directly responsible for this decrease. The objective of the program in subsequent years will be to bring DED fully under control within the control boundaries.

Recommendations for 1978 are as follows:

1) An additional two years of research should be devoted to the integrated control program. At the end of this period, the CSB should assume sole responsibility for conducting the program, with research staff from GLFRC providing only occasional advisory services.

2) Data collected on individual elms within the control boundaries should be computerized to facilitate information retrieval and the conducting of the annual survey of elms for DED.

3) It is obvious that certain areas within the control boundaries are more important than others. In the past, these areas have received greater attention and therefore have experienced fewer losses of elms to DED. Therefore, it is recommended that additional areas within the control boundaries be designated for special attention or intensive management.

4) The feedback from municipalities following publication of the first report in this series clearly suggests that a report solely on the establishment of a DED control program is in order. There is no publication at present which describes the establishment of a DED control program for a municipality and itemizes the resources required.

5) Further investigation of the analysis areas (page 5) should be undertaken to determine what factors make certain areas more susceptible to DED than others.

6) It has been observed that fresh elm chips used for mulch have attracted the native elm bark beetle on at least one occasion; further investigation should be undertaken.

7) A number of high-value elms should be selected in Area E, within the city's DED control area.

APPENDICES

APPENDIX 1

TREATMENT ACTION SHEET

DISEASED ELM SURVEY

Date: ______________________ Zone: ______________________

Location: ____

____

____

Height: ____________________ DBH: ______________________

High-Value Elm: __________________ (o✓f) Tag No.: ____________________

✓ off

Diseased ____________________(Mark Red) Mark tree above eye level with marking.

Suspect ____________________(Mark Green) Paint spot 4" in diameter.

Remarks: ____

____

____

____

Signature: ______________________

Turn white copy in every week
to Bellevue Workyard Office

ACTION TO BE TAKEN: ____

____

____

____

____

____

Date: ______________________ Signature: ______________________

APPENDIX II

19__ DUTCH ELM DISEASE SURVEY

Tree No.	Date	Height	DBH	Section	Municipal Private	Owner	Address	Tree Location	Plan Number	Roll Number

APPENDIX III

REMOVAL SCHEDULE

Tree No.	Date Notification Out	Date Notification Returned	Date Work Order Out	Work Order Number	Date Completed	Remarks