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

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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SAULT STE. MARIE, ONTARIO

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DEPARTMENT OF THE ENVIRONMENT

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FOREWORD

This report is the third in a series outlining a joint venture by the Corporation of the City of Sault Ste. Marie, Ontario and the Canadian Forestry 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.

The downward trend in the incidence of Dutch elm disease has continued into the third year of this program. The program will continue for one more year (1980), to ensure that Dutch elm disease is fully under control within the city's control zone.

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

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ABSTRACT

This report describes progress during the third year of 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 measures are put into practice in an integrated manner. Efforts during the third year have resulted in a continued decline in Dutch elm disease incidence within the control boundaries.

RÉSUMÉ

Ce rapport décrit les progrès réalisés pendant la troisième année de fonctionnement d'un programme de lutte contre la maladie hollandaise de l'Orme, entrepris conjointement par la ville de Sault Ste-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 troisième année ont effectué un declin de l'incidence de la maladie dans les limites de la zone expérimentale.

ACKNOWLEDGMENTS

The integrated DED control program working group gratefully acknowledges the assistance provided by members of the 1978 DED Job Corps program and their leader, Mr. Jim Wiskin. Their efforts in the DED survey are particularly appreciated.

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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 Prince Edward Island, 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 Ontario communities, between 50 and 80% of the publicly owned trees are elms, 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 tree species. 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 indicates a 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 10 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 into 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 third, 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:

Community Services Board, City of Sault Ste. Marie

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

Great Lakes Forest Research Centre

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 could be directed to the individuals involved in the integrated control program. The addresses of the two participating agencies are as follows:

Community Services Board
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Box 580
Sault Ste. Marie, Ontario
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Canadian Forestry Service
Great Lakes Forest Research Centre
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SUMMARY OF 1977 RECOMMENDATIONS

The following recommendations were made for consideration in 1978 and subsequent years; most were implemented in 1978 wherever it was feasible.

(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 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 should be undertaken to determine which 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 F, within the city's DED control area.

SUMMARY OF ACCOMPLISHMENTS IN 1978

The downward trend in the loss of trees to Dutch elm disease continued in 1978. A total of 269 elms, representing 3.4% of the original population of elms within the control area, were removed. The decrease of nearly 25% in the number of elms removed in 1978, as compared to 1977 removals, as well as the smaller diameter of the tree cut, reduced the overall cost of the 1978 sanitation program. Elms removed in the sanitation program continued to be utilized for playground equipment and for wood chips for mulching shrub beds and playgrounds. In addition, small quantities of logs were marketed for lumber.

The system of monitoring elms for the presence of DED continued to be improved in 1978. The key to the effectiveness of DED scouting within the sanitation program was found to be intensive coverage of the control area by well trained personnel. In addition, it was determined that elms suspected of having DED must be cultured to ensure that trees are not removed unnecessarily. Only 47% of the suspect elms sampled and cultured in 1978 were found to be diseased.

The downward trend in native elm bark beetle activity that began in 1976 continued in 1978 and was at its lowest level since monitoring began in 1973. However, significant numbers of European elm bark beetles were captured with pheromone traps within the control zone in 1978--more than was previously the case in this area. Nevertheless, a direct relationship was shown between tree loss and an index of native elm bark beetle activity.

Dursban 2E® was registered in Canada in 1978 for the control of native elm bark beetles. In addition, it was demonstrated that a 0.5% chlorpyrifos full-tree spray was effective throughout a single season for preventing branch feeding by the native elm bark beetle.

Intensive control measures such as MBC-P injections and basal sprays with Dursban to control the overwintering native elm bark beetle have greatly reduced the elm loss rate in a number of areas located within the control zone, immediately adjacent to St. Mary's River. Eighty-three elms were injected during 1978, at an average cost per tree of $157.22. Of the 66 high-value elms injected, 61 were treated prophylactically and five therapeutically. In addition, 52 elms were added to the list of high-value elms during 1978, bringing the total to 181. Of the 17 high-value elms removed in 1978, all but one had not recently undergone injection treatment. No new plantings of elms were initiated in 1978. Also, initial field testing in 1978 of the 'urban elm', a variety of Siberian elm, demonstrated that this particular selection grew with poor form and vigor within the city of Sault Ste. Marie.

ACCOMPLISHMENTS IN 1978

ANALYSIS OF ELM LOSSES RESULTING FROM DUTCH ELM DISEASE IN 1976, 1977 and 1978

Data on elm removals resulting from Dutch elm disease prior to and including 1977 were presented in reports O-X-268 and O-X-283. In this report the data have been updated to include elm removals in 1978 that were due to DED (see Table 1). The table shows that DED incidence increased over that of the previous year in only two of the analysis areas (areas #19 and #26). All other analysis areas showed considerable decreases in DED incidence in 1978. Figures 1 and 2 show analysis areas with elm losses in 1978 of 8% or greater and 5% or less, respectively. Generally, losses due to DED have been greatest along St. Mary's River, where the elevation is roughly 180 m above sea level; the fewest losses have been reported in the higher portion of the city where the elevation is roughly 210 m above sea level. When the figures above are compared with figures 3 and 4, which show analysis areas with 200 or more elms (1968) and 100 or fewer elms (1968), respectively, it is evident that elm density does not necessarily account for the differences in elm loss over the last 11 years.

Areas 3 and 17, though located along St. Mary's River, show a loss rate of only 3.7 and 5.8, respectively, which is considerably lower than loss rates in the other analysis circles along the river. Areas 3 and 17 should have suffered elm losses much greater than 5% but intensive control measures in these areas such as MBC-P injections and basal sprays with Dursban to control the overwintering bark beetle have greatly reduced the elm loss rate from the previous years when losses in the same analysis circles were as high as 12.8 and 15.1, respectively. Table 2 presents a breakdown of numbers of high-value elms in each analysis area and the numbers of elms that have been injected with MBC-P.

Table 1. Percentage loss of elms in 1976, 1977 and 1978 in the analysis areas within the DED control boundary.

Analysis area	Original no. of elms (1969)	Total % loss 1968-1975	% loss 1976	% loss 1977	% loss 1978	No. of elms lost to DED 1978	No. of original (1969) elms remaining in 1978	"New" elms resulting from natural regeneration	Actual no. of elms 1978
1	509	28.1	10.0	12.6	10.0	51	64[a]	13	77
2	34	17.6	3.0	23.5	2.9	1	18	8	26
3	438	30.6	12.8	11.4	3.7	16	182	0	182
4	134	45.5	8.2	0.8	0.8	1	60	204	264
5	316	28.8	20.3	28.8	8.5	27	43	189	232
6	67	59.7	4.5	6.0	1.5	1	19	13	32
7	224	35.3	18.8	25.9	9.8	22	23	138	161
8	516	17.3	3.3	17.2	3.7	19	180[b]	11	191
9	112	33.9	15.2	13.4	8.9	10	32	96	128
10	171	39.2	19.3	18.7	11.7	20	19	62	81
11	385	10.1	2.6	8.3	4.7	18	286	185	471
12	132	38.8	16.7	7.6	8.3	11	38	32	70
13	92	64.1	27.2	8.7	2.2	2	0	81	79
14	84	10.7	15.5	9.5	9.5	8	46	27	73
15	88	10.2	12.5	12.5	4.6	4	53	46	99
16	310	34.2	18.4	35.8	5.8	18	18	110	128
17	186	21.0	15.1	15.1	4.3	8	83	41	124
18	157	32.5	19.7	19.2	12.1	19	26	155	181
19	67	17.9	10.4	0.0	4.5	3	45	36	81
20	61	26.3	6.6	8.2	1.6	1	35	15	50
21	100	35.0	24.0	19.0	17.0	17	5	152	157
22	174	26.4	15.5	14.4	4.0	7	69	57	126
23	50	24.0	16.0	14.0	4.0	2	21	35	56
24	361	13.9	6.6	18.3	5.5	20	201	158	359
25	63	25.2	11.0	15.9	3.2	2	28	147	175
26	100	21.0	16.0	2.0	9.0	0	12[c]	11	23
27	620	22.2	16.9	12.9	7.7	48	248	258	506
	5551[d]						1852	2280	4132

[a] 111 elms removed for development of residential subdivisions and industry.
[b] 136 elms removed for development of residential subdivisions.
[c] 40 elms removed for various land development projects.
[d] Some elms are counted twice since analysis areas overlap in some cases. Therefore, there are in reality fewer than 5551 elms in the 27 analysis areas.

Analysis areas with elm losses of 8 percent or greater

Analysis area no.	Initial no. of elms (1968)	No. of elm losses (1978)	Percent loss (1978)
1	509	51	10.0
5	316	27	8.5
7	224	22	9.8
9	112	10	8.9
10	171	20	11.7
12	132	11	8.3
14	84	8	9.5
18	157	19	12.1
21	100	17	17.0
26	100	9	9.0

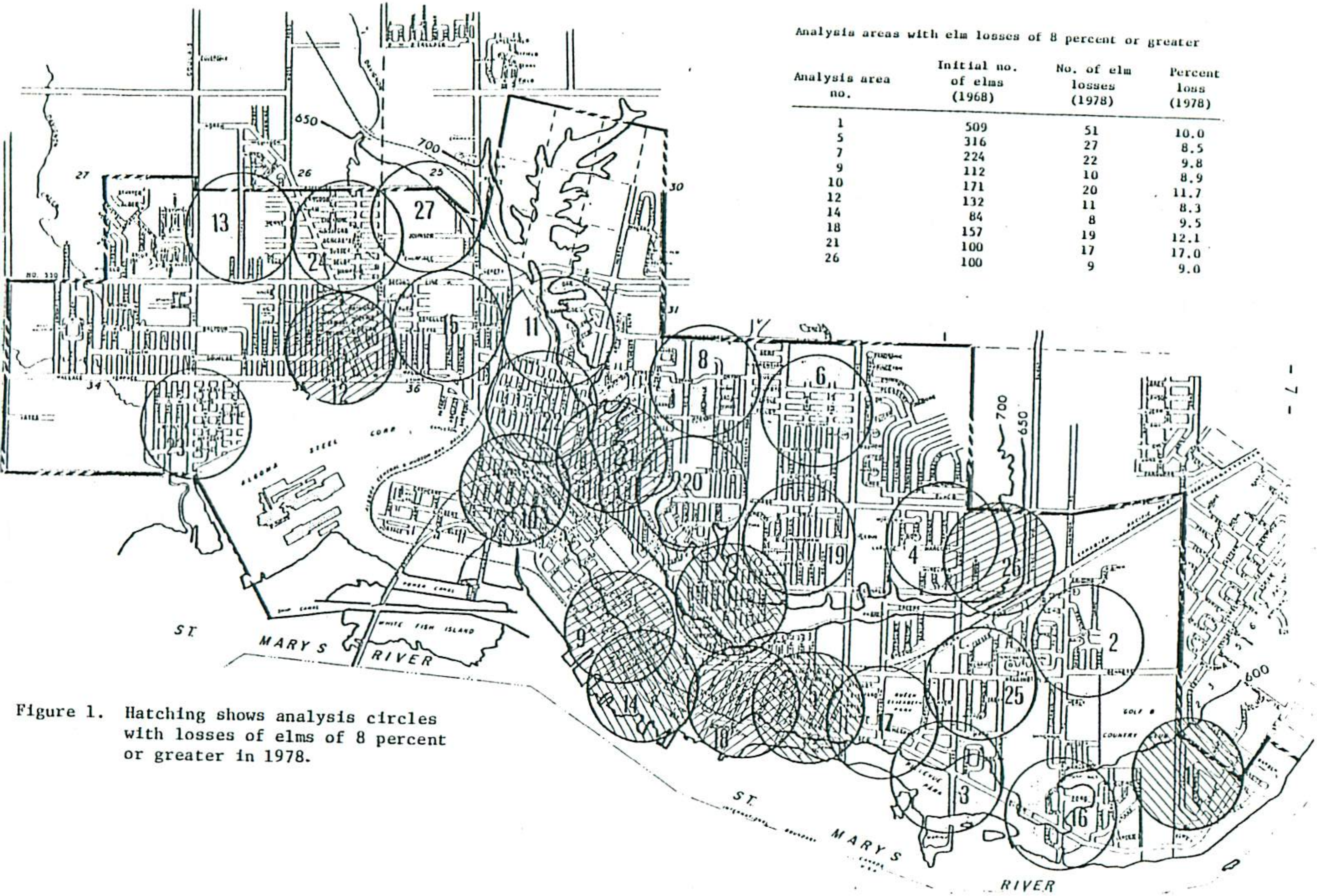
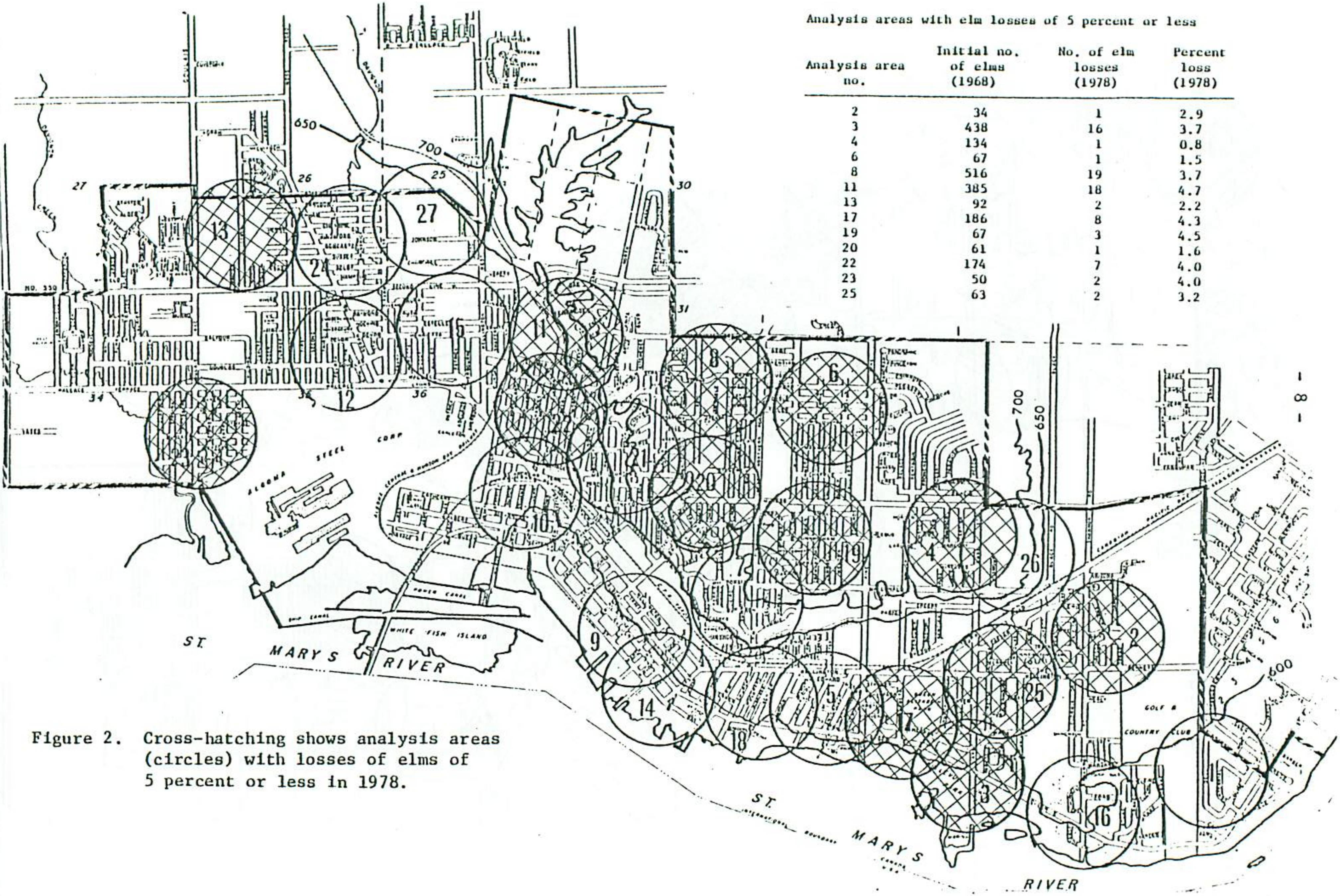


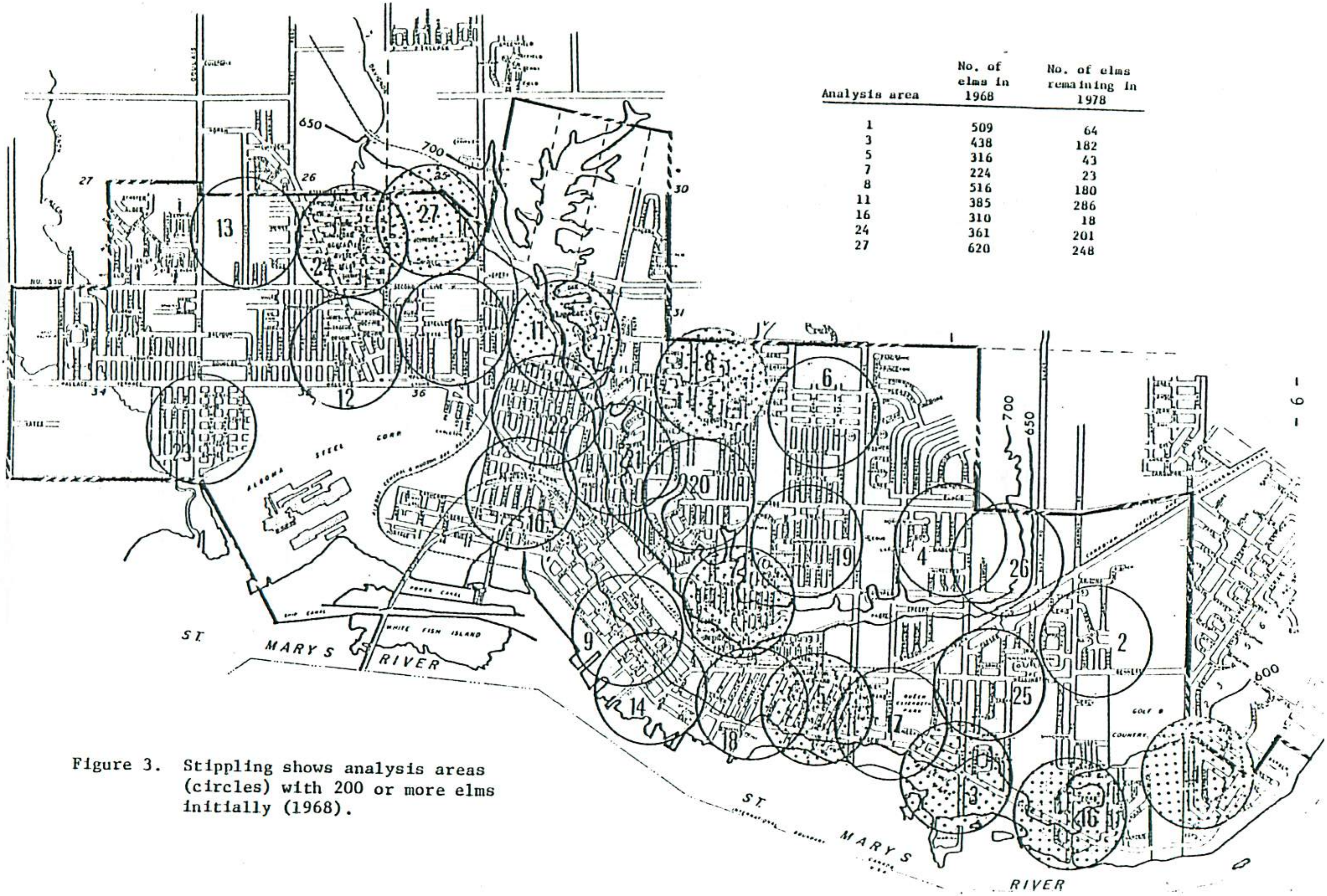
Figure 1. Hatching shows analysis circles with losses of elms of 8 percent or greater in 1978.



Analysis areas with elm losses of 5 percent or less

Analysis area no.	Initial no. of elms (1968)	No. of elm losses (1978)	Percent loss (1978)
2	34	1	2.9
3	438	16	3.7
4	134	1	0.8
6	67	1	1.5
8	516	19	3.7
11	385	18	4.7
13	92	2	2.2
17	186	8	4.3
19	67	3	4.5
20	61	1	1.6
22	174	7	4.0
23	50	2	4.0
25	63	2	3.2

Figure 2. Cross-hatching shows analysis areas (circles) with losses of elms of 5 percent or less in 1978.



Analysis area	No. of elms in 1968	No. of elms remaining in 1978
1	509	64
3	438	182
5	316	43
7	224	23
8	516	180
11	385	286
16	310	18
24	361	201
27	620	248

Figure 3. Stippling shows analysis areas (circles) with 200 or more elms initially (1968).

Analysis areas with 100 or fewer elms in 1968	No. of elms in 1968	No. of elms remaining in 1978
2	34	18
6	67	19
13	92	0
14	84	46
15	88	53
19	67	45
20	61	35
23	50	21
25	63	28

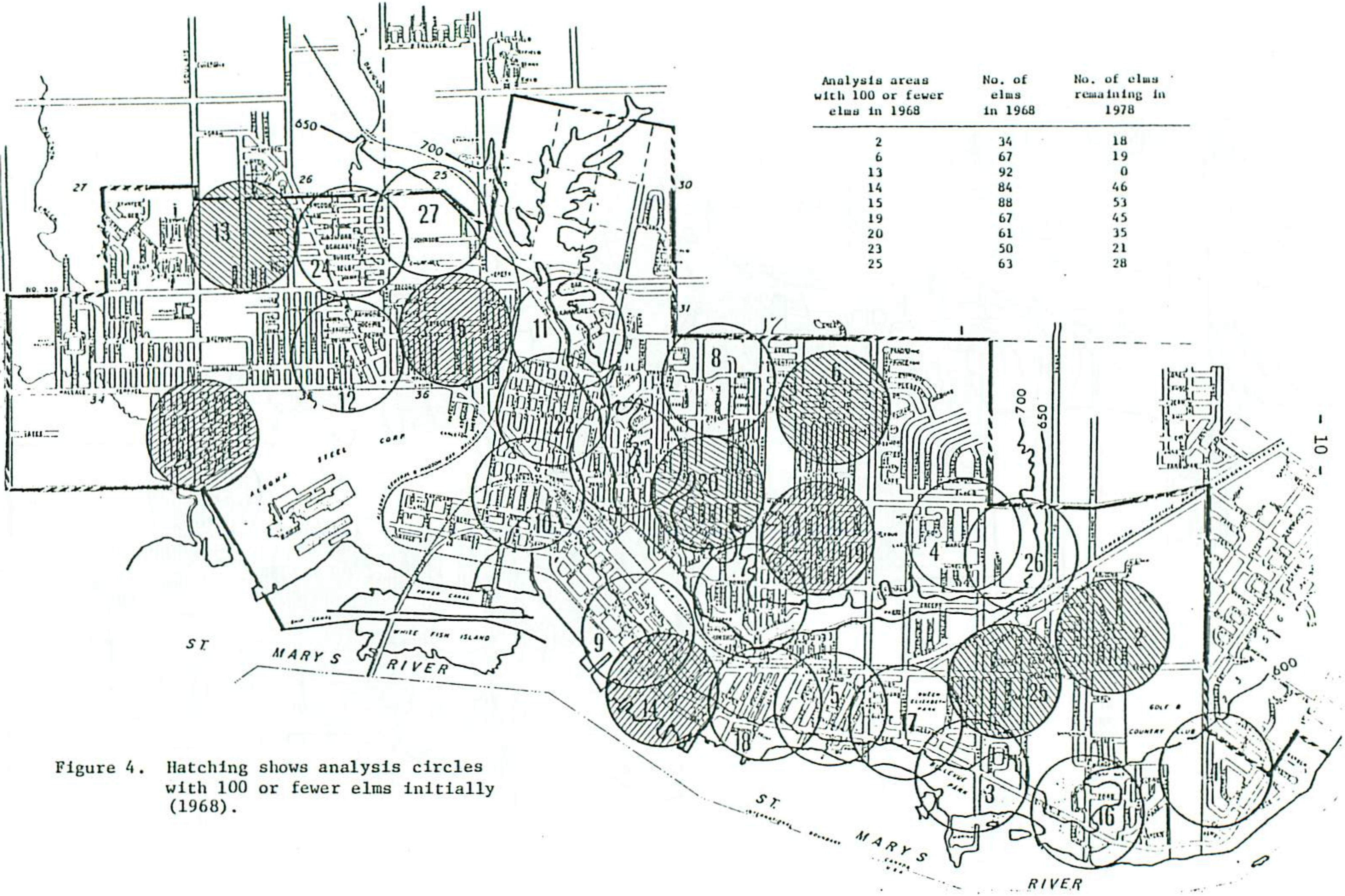


Figure 4. Hatching shows analysis circles with 100 or fewer elms initially (1968).

Table 2. Number and percentage of high-value elms injected with Lignasan-BLP in each analysis area.

Analysis area no.	Total no. of original (1969) elms remaining in 1978	No. of high-value elms	No. of high-value elms injected[a]	% of elms injected
1	64	0	0	0.0
2	18	0	0	0.0
3	182	39	28	15.4
4	60	0	0	0.0
5	43	23	14	32.6
6	19	0	0	0.0
7	23	2	2	8.7
8	180	5	0	0.0
9	32	9	4	12.5
10	19	8	3	15.8
11	286	0	0	0.0
12	38	7	3	5.3
13	-2	0	0	0.0
14	46	25	5	10.9
15	53	1	1	1.9
16	18	0	0	0.0
17	83	13	5	6.0
18	26	16	15	57.7
19	45	0	0	0.0
20	35	0	0	0.0
21	5	1	1	20.0
22	69	5	0	0.0
23	21	0	0	0.0
24	201	0	0	0.0
25	28	0	0	0.0
26	12	0	0	0.0
27	248	1	1	0.4

[a]Fourteen high-value elms are located in overlapping analysis circles. Nine of these have been injected.

Each analysis circle encompasses an area of 71.68 ha; therefore, the 27 analysis areas comprise 1935.4 ha[1], or 66.8% of the total Sault Ste. Marie control area. The percent loss due to DED for all elms within the analysis areas is 6.6% for 1978. However, the percent elm loss for the entire Sault Ste. Marie control area is only 3.4%. This discrepancy arises because the overall percent loss is based only on valued elms (low-value trees, generally of small diameter; trees in uninhabited woodlots and ravines are not included) for the entire control area whereas the percent loss for the 27 analysis areas is based on all elms over 5 cm DBH.

The darkened areas in Figure 5 show the "wild" elm areas within the control boundary. It can be readily seen that many of the analysis areas contain large sections of wild elm areas. Of the total of 1,620 elms greater than 5 cm DBH, approximately 775 or 47.8% are located in wild elm areas within the analysis areas. Therefore, the percent loss of 6.6% could be corrected by a factor of 52.2%, for a percent loss of 3.4% for the 27 analysis areas (which is identical to the 3.4% loss for the entire control area). Hence these 27 analysis areas provide a very representative picture of the situation in Sault Ste. Marie.

Of the 5,551 original 1968 elms within the 27 analysis areas only 1,852 or 33.7% remain; however, during this period 287 were removed for development of land for subdivisions and industrial purposes. Therefore, loss due to DED since 1968 is actually 61.5% within the 27 analysis areas. However, resurveys have shown that there are now 2,280 additional elms within the 27 analysis areas. These elms, all greater than 5 cm DBH, have regenerated mostly since the 1968 original elm survey. During the 1968 original elm survey only trees over 11.4 cm DBH were counted. Elms grow very rapidly in diameter especially once they reach sapling size. It is not practical to carry out a resurvey every year, although elms are continually growing into the countable diameter class. Therefore, it is suggested that a resurvey be conducted every 5 years and should include all elms over 5 cm DBH, to compensate for the rapid growth of elms.

Adding the new elms (2,280) recorded in the most recent survey to the number of original elms remaining (1,852) gives a total of 4,132 elms within the 27 analysis areas. Hence, after 10 years of DED and removal of 61.5% of the original elm population, Sault Ste. Marie still has 74.4% of the initial number of elms within the analysis areas. It should be noted, however, that there has been a significant shift of the elm population to the smaller diameter classes.

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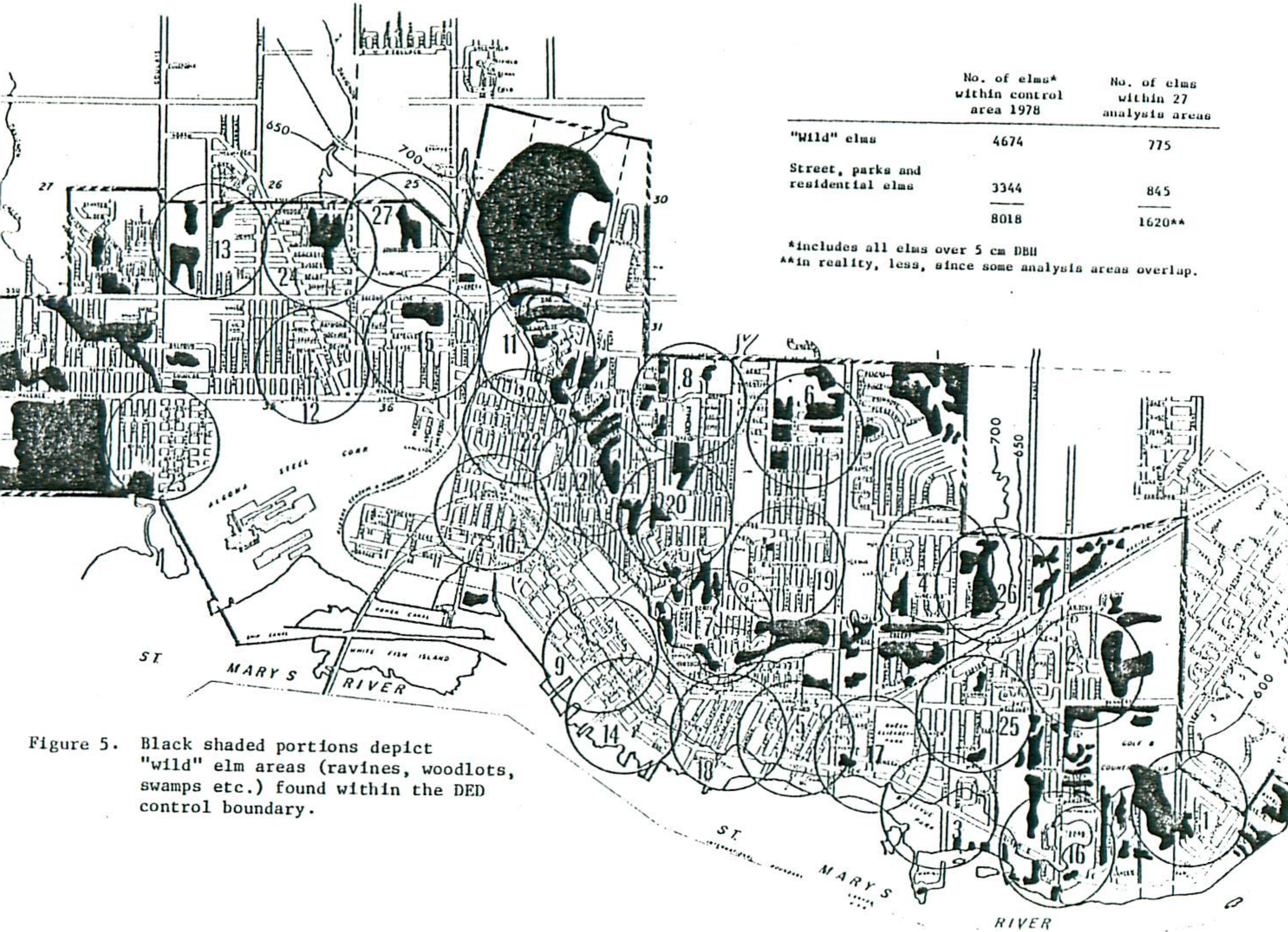
[1]In reality much less, since some analysis areas overlap.



	No. of elms* within control area 1978	No. of elms within 27 analysis areas
"Wild" elms	4674	775
Street, parks and residential elms	3344	845
	8018	1620**

*includes all elms over 5 cm DBH
**in reality, less, since some analysis areas overlap.

Figure 5. Black shaded portions depict "wild" elm areas (ravines, woodlots, swamps etc.) found within the DED control boundary.

From the above it is evident that present methods of calculating percent loss are not fully satisfactory. Traditionally, calculation of percent elm loss each year has been based on the original elm population in year one or on the elm population at the beginning of each year in question. However, both methods of calculation have their disadvantages as the years progress. For instance, in the first case if we started with 8,000 elms and in the 30th year we have only 100 elms left, then the loss of 10 would result in a percent loss of 1.25. On the other hand, if we calculated the percent loss on the basis of the number of elms alive at the beginning of the 30th year we would have a percent loss of 10. In this case as the number of elms decreases even more the percent loss becomes even more meaningless. For instance, if there are only 10 elms left and two elms are lost to DED we would have a percent loss of 20. Both methods of calculating percent loss become meaningless as time progresses. Therefore, it is suggested that the percent loss be calculated on the basis of the actual number of elms within the control area at the end of each 5-year period. This would take into consideration elms volunteering and being planted in the control area. Also, yearly improvement in the success of any control methodologies employed would become more evident.

In the previous year's report (0-X-283), the status of elms in Bellevue Park was given for the first time as an example of an area of intensive management to control DED within the Sault Ste. Marie DED control boundary. In this report we have updated these data in an attempt to provide some continuity for those who are following the progress and success of the work. Figure 6, which shows elm removals for 1978, is an update of the figure used in Report 0-X-283. Five elms, including one injected with MBC-P, were lost to DED in 1978. Hence, the percent loss for 1978 in Bellevue Park is 2.6 (based on the original number of elms in 1968, i.e., 192). It is evident from this example that intensive management within the control boundary is worthwhile for a further reduction of loss to DED in high-value areas.

SELECTION OF HIGH-VALUE ELMS

There were no changes in the criteria for the selection of high-value elms. Table 3 indicates the number and general location of high-value elms selected in 1976, 1977 and 1978. The locations of the high-value elm monitoring sections are shown in Figure 7.

The total number of high-value elms as of July 20, 1979 was 181. With the addition of 52 elms in 1978 there are now high-value elms in all sections of the Dutch elm disease control area. Of the 17 elms removed during 1978-1979, 11 had received no chemical treatment since the initiation of the control program, one had not been treated since 1976 and 4 had not received any treatment in 1978, although they had been treated in the previous two years. One elm that had been diseased

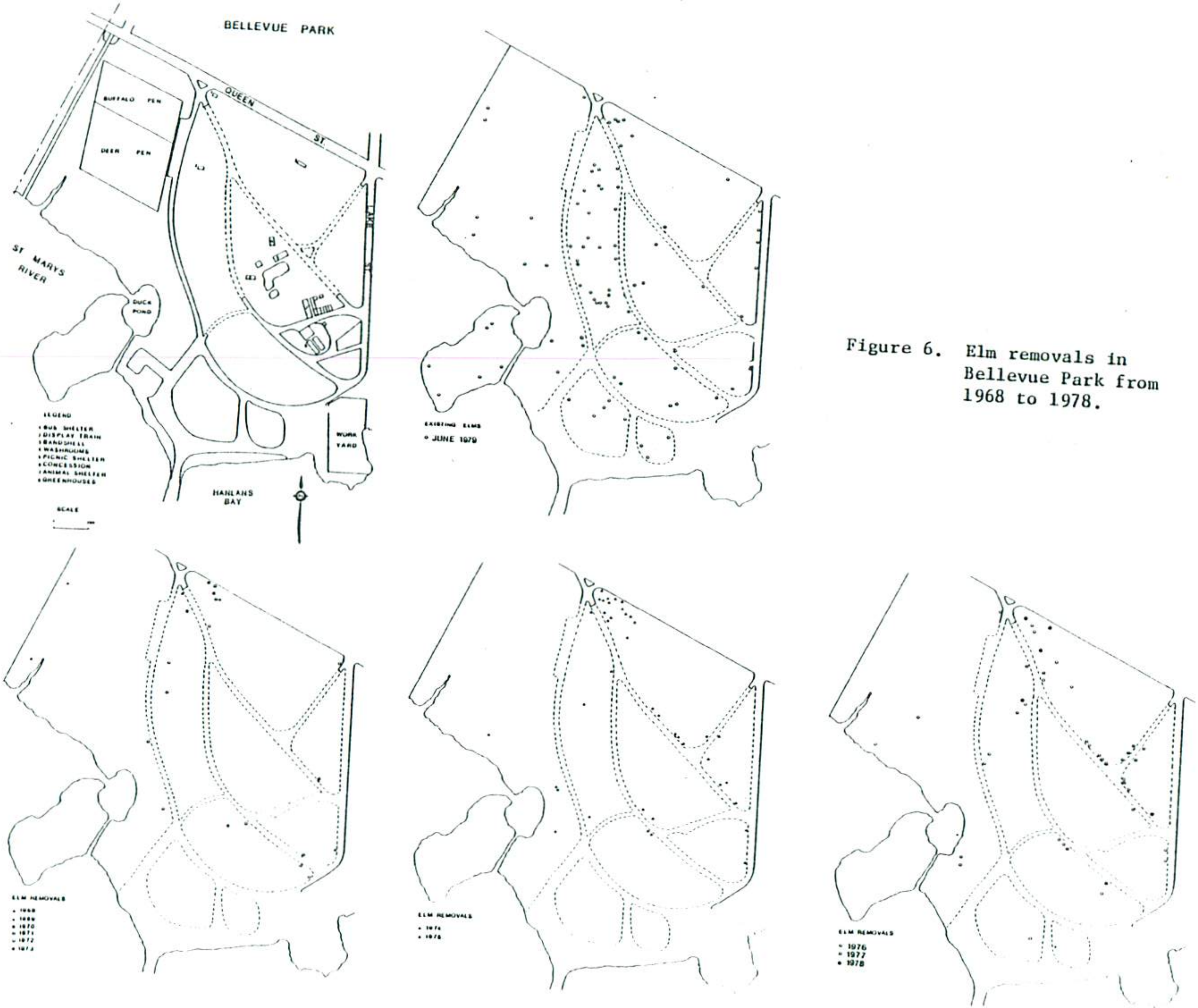


Figure 6. Elm removals in Bellevue Park from 1968 to 1978.

Table 3. Numbers and distribution of high-value elms within the city of Sault Ste. Marie Dutch elm disease control area selected and removed between 1976 and 1979.

High-value elm monitoring sections within control area	Number of high-value elms selected			Number of high-value elms removed			Number of high-value elms as of July 20, 1979
	1976	1977	1978	1976-77	1977-78	1978-79	
A	58	15	12	1	7	5	70
B	48	--	--	8	6	3	31
C	22	1	24	0	1	4	42
D	9	--	5	1	0	4	9
E	21	--	7	1	3	1	23
F	0	--	4	-	-	-	4
Total	158	16	52	11	17	17	181

since 1976 was removed in 1978-1979. Unfortunately in the latter case, the tree could be only partially root injected, and in fact, in 1978 it received only root flare injection, even though it was known to be diseased.

Table 4 indicates the distribution of injected high-value elms. The majority of treated elms, as well as the majority of those selected as high-value elms, are located in sections A, B and C. These areas contain the majority of the older sections of town plus most of the well established public parks and other public buildings.

A large percentage of the selected high-value elms do not receive injection treatments on an annual basis and may therefore require an alternative type of treatment that is currently available within the control program. Consequently, an effort should be made to develop an evaluation system that would classify each high-value elm according to its suitability for the various treatment methods available. A system of this nature would assist in the overall management of the Dutch elm disease control program. An improved system of labelling elms should be developed to alleviate the chronic difficulties involved in positively identifying and locating selected high-value trees. Numbered, punched brass tags become oxidized and difficult to read one year after treatment. Consequently, the high-value trees in some instances become difficult to locate, particularly for temporary employees such as summer students, who have no long-term familiarity with the selected elms. The use of photographic identification techniques should be investigated as one means of facilitating the identification of high-value elms.

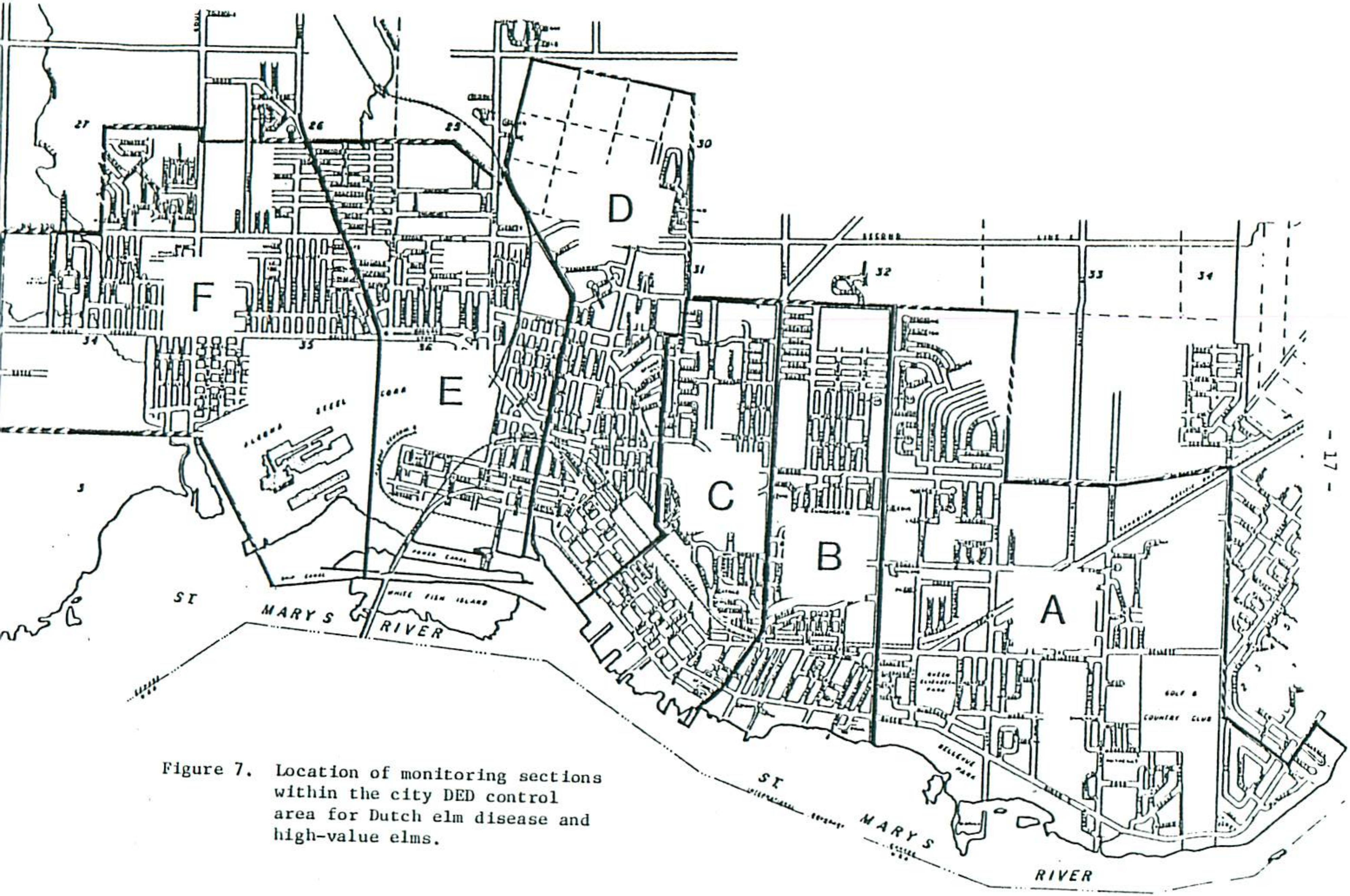


Figure 7. Location of monitoring sections within the city DED control area for Dutch elm disease and high-value elms.

Table 4. Numbers and distribution of high-value elms injected within the city of Sault Ste. Marie Dutch elm disease control area

High-value elm monitoring sections within control area	Injected elms						
	1976		1977		1978		
	Number	% of high-value trees in sections	Number	% of high-value trees in sections	Number	% of high-value trees in sections	Total
A	14	24.1	39	54.2	40	52.6	93
B	10	20.8	27	67.5	14	41.2	51
C	8	36.4	10	43.5	4	8.7	22
D	1	11.1	4	50.0	3	23.1	8
E	5	23.8	6	30.0	5	20.8	16
F	0	0.0	0	0.0	0	0.0	0
Total	38	24.1	86	52.8	66	33.5	190

Tree marking paint is employed to indicate the status of elms within the Dutch elm disease control zones. Unmarked trees are considered healthy. Trees with a yellow dot at their base are healthy selected high-value elms. High-value elms suspected of being diseased are painted (at breast height) with a green dot 10 cm in diameter. If subsequent sampling indicates that the tree is diseased, and if the tree is not subjected to an injection treatment, it is marked with a red dot for removal. If repeated sampling and culturing demonstrates that the tree was not initially diseased or has regained its health after treatment, the green dot is removed.

For elms on public and private property that are not designated high-value trees, a green dot is applied only if a tree is suspected of being diseased and sampling and culturing are desired. Otherwise, it is marked for removal with a red dot. A green dot may also be applied to trees on private property that are diseased, but are currently treated as part of a disease control program conducted by a commercial arborist.

BEETLE MONITORING

Native Elm Bark Beetle (Hylurgopinus rufipes [*Eichh.*])

Monitoring of beetle activity at selected sites in the control area continued in 1978. Since 1973, periodic counts of beetles on sticky traps have provided an excellent estimate of population trends on the basis of level of beetle activity.

Figure 8 shows the results of six years' trapping at selected stations in Sault Ste. Marie, grouped by location, and spring, summer and fall flights. For an explanation of these seasonal flights and their significance, please consult the first report in this series (Report O-X-268).

The downward trend in activity that began in 1976, and became more noticeable in 1977, continued in 1978 and, in fact, the fall flight last year was much below that of 1973 when monitoring began. This indicates that, because of the virtual disappearance of the wild elm population, we no longer must deal with the former vast influxes of beetles from outside the control area. This augurs well for the establishment of positive DED control in the city. It has been stated often that the short-term objective of DED control is the preservation of a good representation of high-value elms within the control area through the crisis until the disease in the wild elm population no longer poses a threat to the high-value elms. That objective now appears to have been reached in Sault Ste. Marie, and it is to be hoped that these highly desirable trees may be cared for properly in a calmer atmosphere.

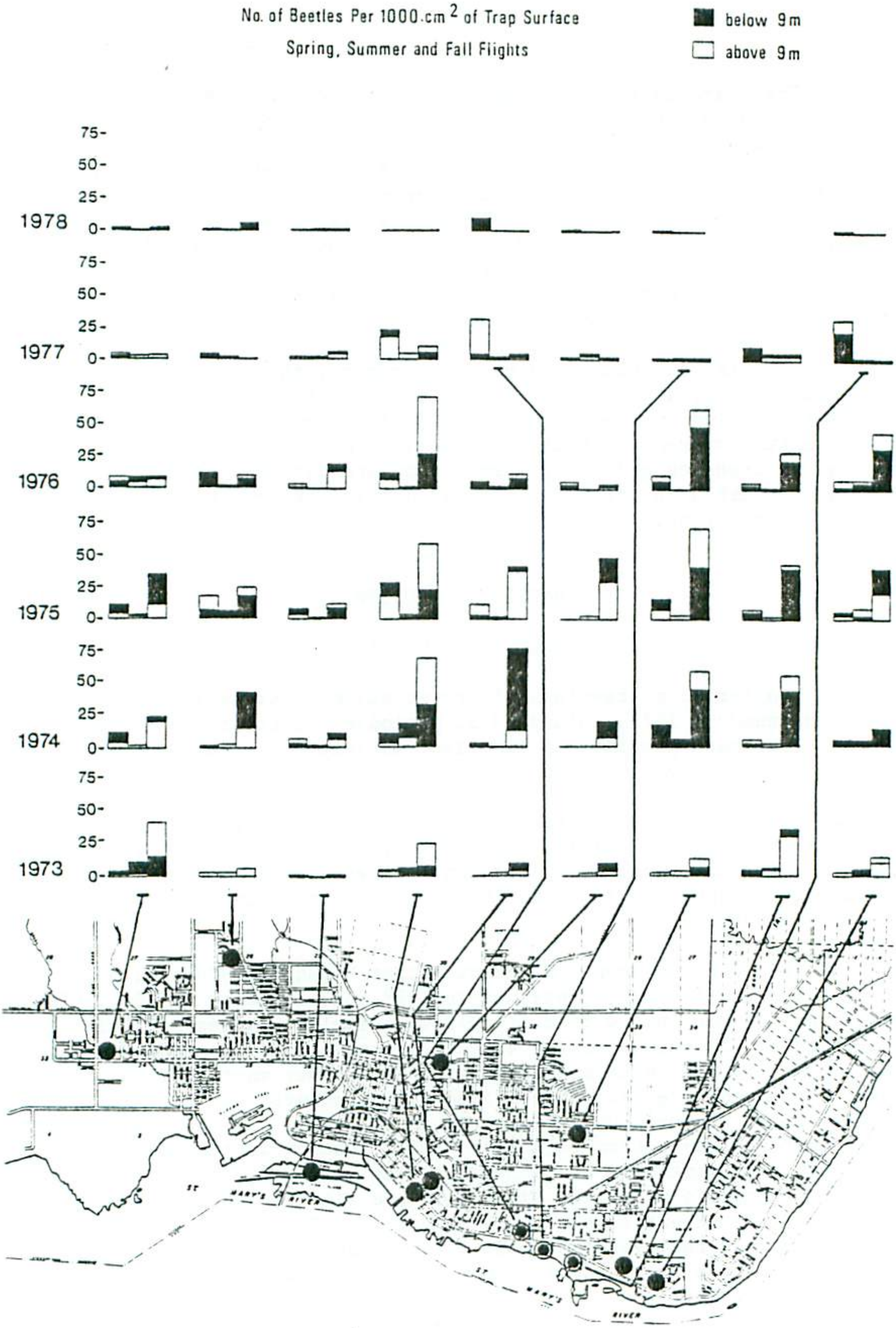


Figure 8. Native elm bark beetle occurrence in elm crowns.

When combined with figures for annual tree loss to DED in the control area, these results of annual beetle monitoring provide an interesting picture of the buildup and decline of a DED outbreak, as well as a graphic demonstration of the relationship between *H. rufipes* and DED.

Figure 9 shows the year-to-year record of beetle activity in Sault Ste. Marie and loss of elms to DED expressed as a percentage of the original high-value elm population. Beetle activity is expressed as an 'index', which is the average number of fall-flight beetles per 1000 cm^2 of trap surface for all trapping stations. The fall-flight beetles were chosen to provide the expression of beetle activity because they form the overwintering adult beetle group (OWA) which previous research at the Great Lakes Forest Research Centre has shown to be the main culprits in DED fungus transmission. The index is thus a real measure of DED hazard.

The size of the fall OWA group, however, affects DED incidence only in the following year. This is illustrated well in Figure 9. The increase in fall beetle activity in 1974 resulted in a greater loss of trees in 1975 than had been experienced previously. A rise in OWA activity in 1975 brought tree loss to a peak in 1976. Since then, reduction in OWA activity has been matched by greatly reduced DED incidence and loss of elms. Figure 9 suggests that one may reasonably expect tree loss in 1979 to drop very close to 0%.

Plotting tree loss against index of beetle activity (Fig. 10) shows clearly, for the first time, the direct relationship between them. Any community with a population of elms similar to that of Sault Ste. Marie could use the curve thus generated to predict loss of trees in any year by establishing the 'index of beetle activity' in the previous year. It may be that Figure 10 portrays only a portion of the true curve of relationship between the two parameters. Clearly, as the beetle activity index is reduced to zero, tree loss due to DED will also approach zero. What happens at the upper end of the curve, however, cannot be known at this time.

It is somewhat reassuring to be able to demonstrate this direct and apparently reliable relationship between *H. rufipes* and loss of elms to DED. This not only reassures that OWA beetle control measures such as trunk treatment with chlorpyrifos are well worthwhile, but also suggests that one need not worry about DED transmission by other possible agents such as sapsuckers.

In addition, the relationship is probably a measure of the efficiency of *H. rufipes* in DED transmission. No such relationship between tree loss and *S. multistriatus* activity has yet been demonstrated. Successful inoculation by this species, leading to a systemic distribution of fungus in the tree, is much more of a chance affair, and may

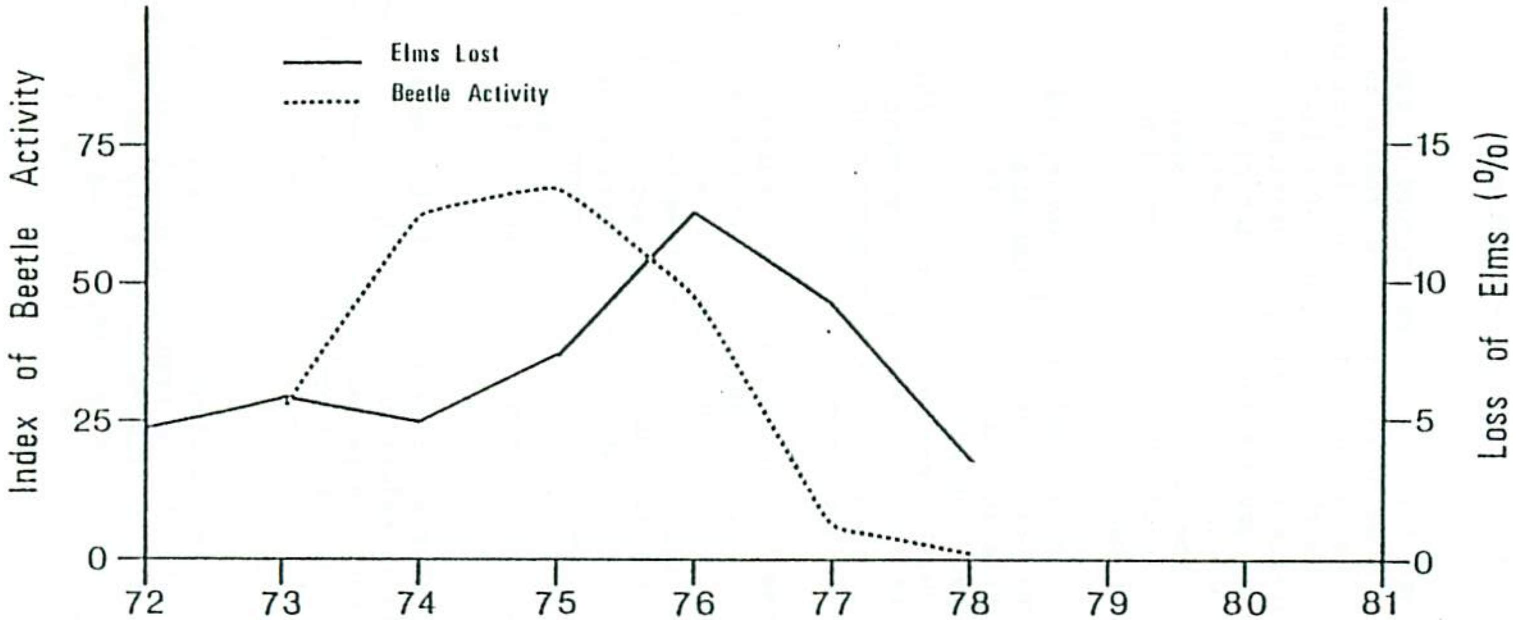


Figure 9. Annual record of the index of native elm bark beetle activity and percent elm loss in Sault Ste. Marie, Ontario 1972-1978.

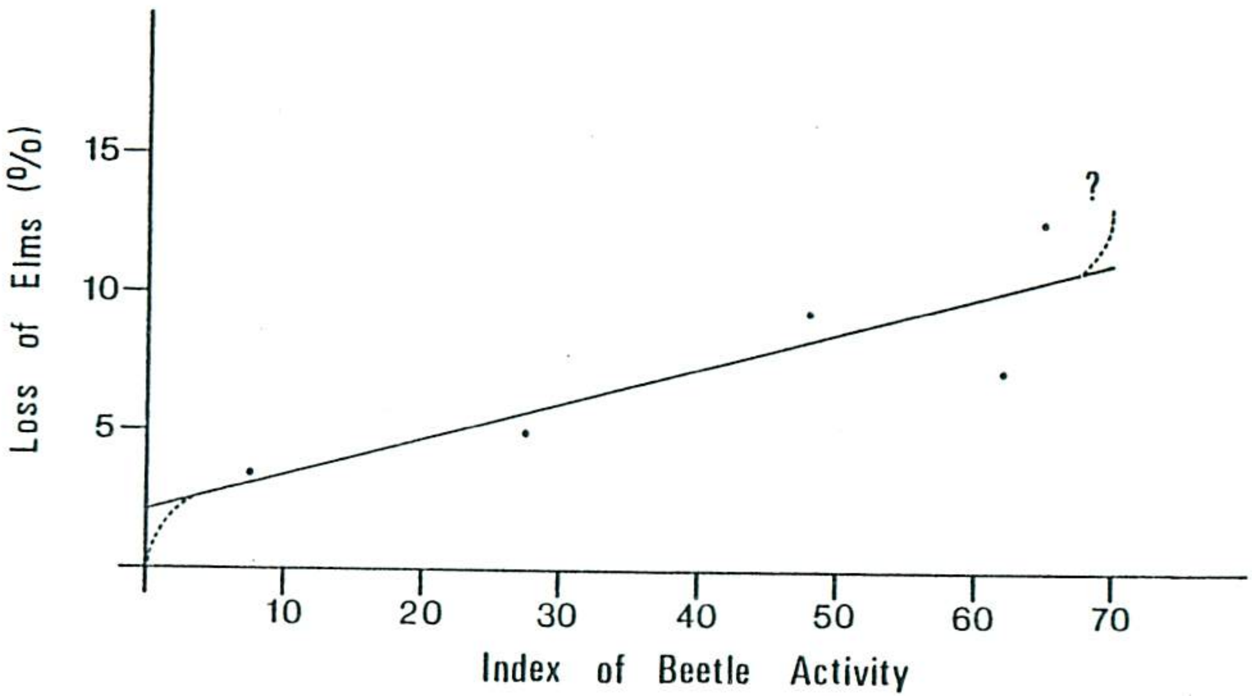


Figure 10. Relationship of the loss of elms to native elm bark beetle activity in Sault Ste. Marie, Ontario.

involve many feeding attacks by thousands of beetles. Hence, it is possible that such a relationship may never be shown in the case of *S. multistriatus*.

European Elm Bark Beetle (Scolytus multistriatus [*Marsh.*])

This species has never been plentiful in the Sault Ste. Marie area in the past. In 1978, however, significant numbers were captured at pheromone traps in the city. After initial captures at GLFRC, traps were set out at selected sites (Fig. 11) throughout the control area on 19 June. These traps consisted of a polyethylene sheet 30 x 50 cm covered with a sticky material, in the centre of which was a small cardboard "tent" housing the plastic pheromone dispenser.

Figure 11 shows the number of *S. multistriatus* captured at the various sites during the 1978 season. In comparison with captures in Ottawa a few years ago with the same kind of trap, these numbers are not particularly impressive; however, they are much greater than those experienced previously in this area.

Where these beetles come from is not definitely known. Except for a minor occurrence in 1970 (Thomas 1971), brood production by this species has not been found. It seems highly unlikely, therefore, that the population detected in 1978 was bred in the control area or environs. More probably the beetles came across the St. Mary's River from Sault Ste. Marie, Michigan, where there is no DED control program and where there were many large dead elms in 1978. This source is also suggested by the fact that the largest number of beetles were caught at the GLFRC site, on the river bank.

BEETLE CONTROL

Control of Overwintering Adults

No further research was done in 1978 on control of overwintering adults of the native elm bark beetle. Early in the season the insecticide Dursban 2E® was registered in Canada for control of native elm bark beetles under P.C.P. No. 10,636 for 1978. This registration permits the application of Dursban 2E® as a 0.5% aqueous mixture of chlorpyrifos to the trunks of elm to prevent beetle overwintering, and to the crowns of high-value elms to reduce branch feeding. The new control method arises from research conducted in recent years at GLFRC and results indicate that it is effective in suppressing overwintering beetle numbers and incidence of branch feeding. Both effects should greatly decrease the chance of new tree infections.

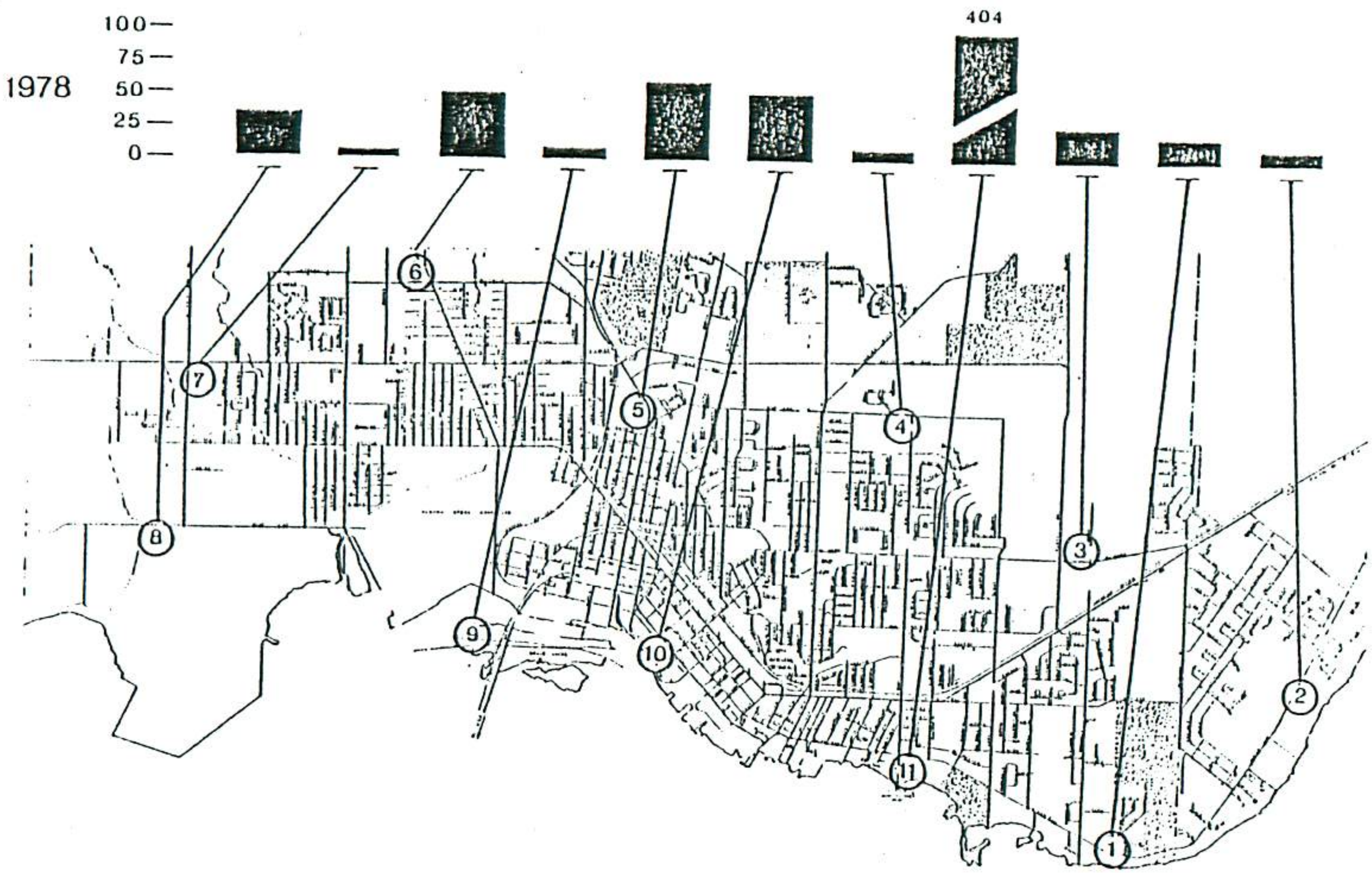


Figure 11. *S. multistriatus* captured in Sault Ste. Marie.

Control of Branch Feeding

On 16 May 1978 the crowns of all elms at the Courthouse were sprayed with a hydraulic sprayer containing a 0.5% aqueous mixture of chlorpyrifos. Ten times throughout the season five sample branches were taken from the sprayed trees and submitted to bioassay for protection against penetration by native elm bark beetles to the xylem tissue (Report O-X-283, p. 16). Each time, a 10 cm^2 sample of bark was taken from the branches, freeze-dried, pulverized and held in freezer storage for chemical assay of chlorpyrifos residues. Chemical assay was provided by Dr. D.P. Webb of GLFRC, who had previously devised the analysis method.

The results of the bioassays were as follows:

Date	Control (%)	Beetle Mortality (%)
17 May	100	100
19 May	86	90
25 May	100	100
30 May	100	100
2 June	100	100
19 June	100	100
7 July	100	100
9 August	0	66
6 September	100	90
8 November	100	90

With one exception, all tests showed that the treatment had provided good protection against branch feeding by *H. rufipes*.

Figure 12 shows the results of chlorpyrifos residue determination. The curve shows the typical, sharp initial decrease in chemical residue after application because of volatilization and chemical breakdown. This is followed by a typical period, usually lasting the season, during which the chemical remains at a fairly constant low, but effective, level. Residue analysis explained the poor bioassay results obtained with the 9 August sample. Most branches in the sample held only trace amounts of chlorpyrifos and these were not effective in preventing beetle penetration through the bark. That these branches were selected by chance alone is shown

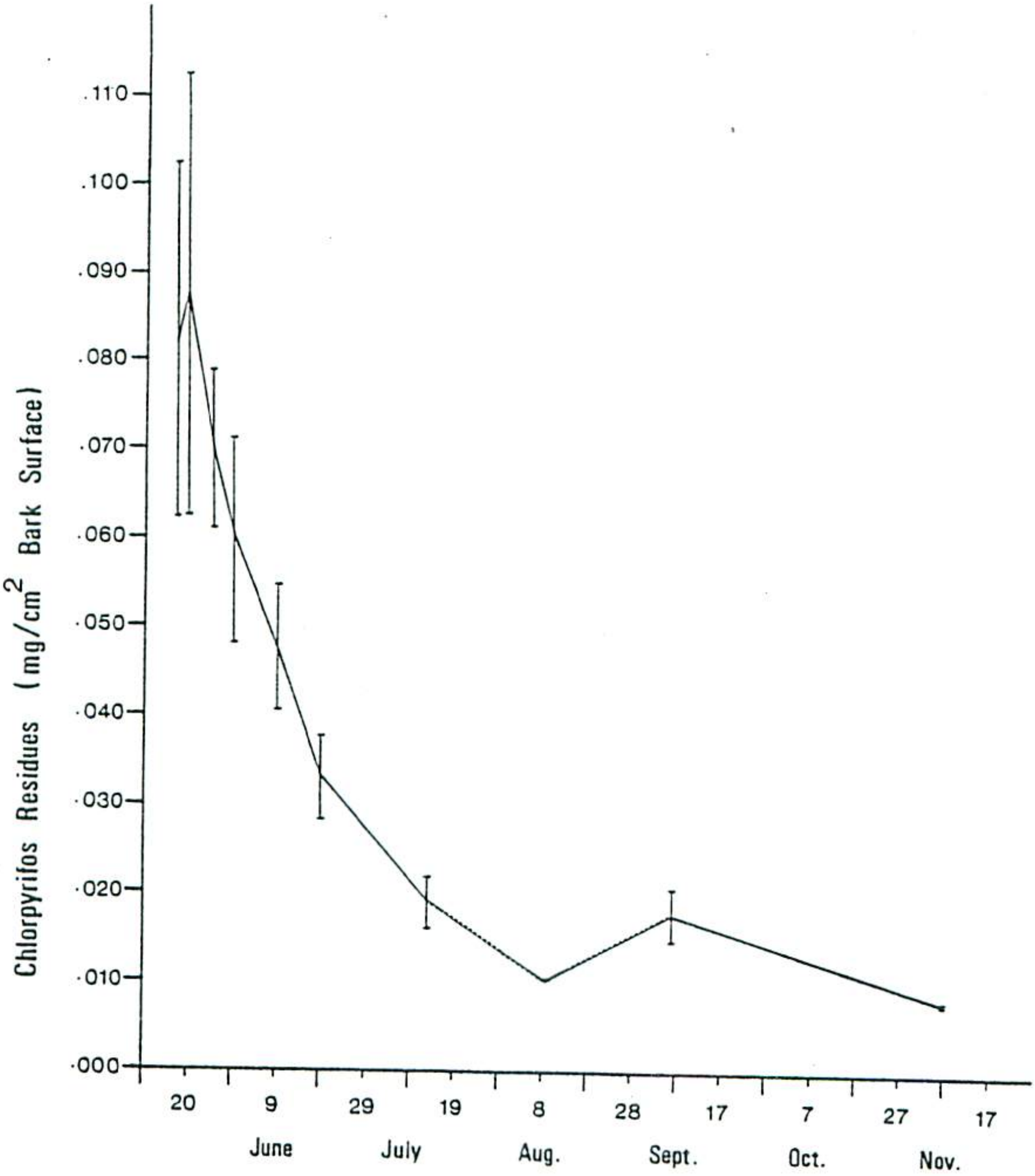


Figure 12. Chlorpyrifos residues on branches of trees sprayed with 0.5% mixture on 16 May, 1978.

by the two perfectly adequate samples taken in September and November. This emphasizes the importance of ensuring thorough coverage during the application.

The experiment shows that a 0.5% chlorpyrifos spray is effective throughout the season for preventing branch feeding by *H. rufipes*. This seems to be the minimum or near-minimum concentration necessary to do the job, however. Because of the reduction in chemical residue by the end of the year, one would not expect that adequate protection would carry over into the following spring. It appears, therefore, that, unlike the trunk spray, crown spray must be applied each year.

SAMPLING AND CULTURING FOR POSITIVE IDENTIFICATION OF DUTCH ELM DISEASE

In previous years sampling and culturing of elms[2] other than high-value elms for positive identification of DED were undertaken only in doubtful cases, because of the large numbers of trees showing disease symptoms. Therefore, it is highly possible that elms not having the disease may have been removed in the past. It must be remembered that elms may exhibit DED-like symptoms and can decline rapidly for a variety of reasons not connected with DED. Other wilt fungi such as *Dothiorella ulmi* Verrall and May and *Verticillium* sp. can cause disease symptoms similar to those exhibited by DED. Severe wetwood in elm can cause wilting, chlorosis and necrosis in part of the crown, especially following fissuring or cracking of the outer healthy xylem tissue as a result of excessive pressures building up internally in the heartwood. Environmental stress, salt and construction damage may also result in symptoms similar to those of DED. Since DED was beginning to be brought under control rapidly in Sault Ste. Marie and the number of elm removals was decreasing, an attempt was made to increase the number of elms sampled and cultured in 1978.

Most of the sampling and culturing for positive identification for DED was undertaken by summer students working for the federal government-sponsored Summer Job Corps Program, specifically the "Forest Management Research, Development, and Public Awareness Program". Two methods of culturing for *C. ulmi* were employed: one involved culturing elm chips on 2.5% PDA plates and the other involved culturing elm sections on sterilized wet filter paper in disposable petri plates. Both methods gave similar results. The latter is favored because it saves considerable time and effort while producing similar results.

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[2]Elms found in woodlots and ravines are not sampled for positive identification of DED.

Table 5 presents a summary of the 1978 sampling and culturing. From a total of 198 suspect elms which were sampled and cultured for the presence of *Ceratocystis ulmi*, 94, or 47%, were found to be positive. As in previous years, the incidence of negative suspect elms was highest in June and August. This can be attributed to dieback in the spring, fall coloring in the fall, and stress symptoms resulting from abiotic factors; hence the importance of culturing elms suspected of having DED to ensure that trees are not removed unnecessarily. This becomes more and more important as the numbers of large elms decrease.

Table 5. 1978 Summary of sampling and culturing for *C. ulmi*.

Month of sample	No. of elms sampled	Isolation of *C. ulmi*	
		Positive	Negative
January	5	4	1
February	2	2	0
March	1	1	0
April	3	1	2
May	0	0	0
June	57	12	45
July	81	60	21
August	49	14	35
Total	198	94	104

CHEMICAL INJECTION OF ELMS

All high-value elms were examined on a weekly basis from 15 June to 1 September. Any new cases of Dutch elm disease were promptly reported to the Community Services Board so that the chemical injection could be undertaken immediately when the disease index was not above 50. A problem occurred in late spring when the disease symptoms tended to spread throughout the elm at a very rapid rate. This period lasted in the Sault Ste. Marie area from the time the Dutch elm disease symptoms were first expressed until approximately 2-3 weeks later.

Because indices could jump 50 to 100 points in 1 or 2 days it was considered advisable to employ 15 as the maximum disease index during this critical 3-week period. Employing this rule of thumb saved a good deal of time and money, because elms that would in all likelihood have disease indices well above 50 by the time they could be fully prepared for injection were not selected.

As shown in Table 6, a total of 83 elms were injected during 1978. Sixty-one high-value elms were treated prophylactically and five therapeutically. Seventeen elms other than high-value elms were chemically injected. Of the 66 high-value elms injected 14 were root injected and 52 were root-flare injected. The total number of diseased trees treated was 12. Five of these were high-value elms and seven were not.

A single Community Services Board tree injection crew, composed of a group leader and three forestry student assistants, carried out all injections. The crew was supervised by the Community Services Board forestry foreman. Using a half-ton truck, equipped with a 900 L reservoir, AC generator and other necessary equipment, the crew worked a 40-hour week for 11 weeks during the period 30 May to 22 August. In all, 83 trees were injected. The average treatment cost of a single elm was $157.22, $13.22 higher than in the previous year. A breakdown of the injection costs is given in Table 7. While an effort was made to reduce costs, a number of factors made this difficult. The operation and maintenance of older injection equipment, the replacement of soil and sod with pea gravel around the root flare area of elms to reduce future excavation costs, as well as continued research-related activities, contributed to an increase in labor costs.

ALGOMA DISTRICT COURTHOUSE

In the previous 5 years the Community Services Board had assumed responsibility for chemically injecting 18 elms at the Algoma District Courthouse. All costs of the program were borne by the Ontario Ministry of Government Services, as the elms are on provincial property. In the spring of 1978 Community Services Board crews assumed responsibility for therapeutically injecting five elms. As the remaining 13 elms appeared healthy, it was decided not to inject them. Whole-tree spraying with Dursban had been carried out as a dormant spray operation earlier that spring. This gave additional protection to all 18 Courthouse trees.

Table 6. Summary of Lignasan-BLP injections, 1978.

High-value elm monitoring sections within control area	Number of elms injected				Total no. injected 1978	Elms reinjected from previous years[a]
	High-value elms		Other elms			
	Therapy	Prophylaxis	Therapy	Prophylaxis		
A	4	36	5	6	51	24
B	0	14	0	0	14	14
C	0	4	3	1	8	4
D	1	2	0	0	3	2
E	0	5	1	1	7	4
F	0	0	0	0	0	0

[a] Reinjected elms are included in the figure for total number injected.

Table 7. Cost analysis for injection, 1978.

Materials and Supplies	Cost
800 L Lignasan-BLP @ $3.33 per L	$ 2,700.00
Shipping cost	$ 93.20
Depreciated cost of two injection units with accessories purchased in 1977 - 30% of cost	$ 312.00
Depreciated cost of plastic injection solution reservoir purchased in 1977 - 30% of cost	$ 60.00
Depreciated cost of AC generator purchased in 1977 - 30% of cost	$ 36.00
Miscellaneous cost	$ 227.00
Total cost of materials and supplies	$ 3,428.20
Labor (actual costs)	
Group leader - 11 man weeks @ $6.02 per hour	$ 2,648.80
3 student assistants - 33 man weeks (approximately) @ $3.80 per hour	$ 4,752.00
Overhead - 30% of labor cost	$ 2,220.24
Total labor cost	$ 9,621.04
Total injection costs for 1978 for 83 elms:	$13,049.24
Cost per injected tree:	$ 157.22

Operational difficulties arose because the five trees that were injected were in very poor condition at the time of treatment, the initial chemical uptake rate was low, and injection units and equipment were required elsewhere. To overcome this problem, we decided to move our equipment to other trees and to contract out the injection of the Courthouse trees. This alleviated the problem. It is recommended that contracting be employed more extensively whenever municipal equipment, time or manpower is required elsewhere.

SCOUTING FOR DED

The importance of an efficient scouting system for diseased trees becomes more evident every year the integrated program operates. An efficient scouting system is the key to a good sanitation program.

Prior to the implementation of the integrated DED program, general scouting was carried out by the Community Services Board using one and periodically two forestry students. This method was not completely effective because many areas were checked only once and diseased trees could be, and in fact were, missed. Starting in 1976 the integrated program staff provided additional backup assistance in the form of weekly scouting of selected sections of the control zone. This system was further improved with the use of Treatment Action Forms (Appendix I, Report O-X-283) in 1977 and provided even more reliable coverage, especially in ravine and woodlot areas. These improvements all helped but the working group concluded that more intensive coverage was required because misses were still evident.

The 1978 program provided the most intensive coverage to date. The Great Lakes Forest Research Centre, using a crew of university students funded as part of a federal government Job Corps Program, intensively and systematically scouted the control area from early June to mid-September. Working under a group leader in allocated sections, each scout checked all pre-mapped elms on a regular basis and reported information on diseased trees or those suspected of being diseased on a Treatment Action Form. Information such as date, location, height, DBH, map number and special remarks was recorded. These forms were forwarded weekly to the Community Services Board chief scout who followed up these sightings and, if the results were confirmed, marked the tree at eye level with a red circular spot if it was diseased or with a green spot if there was some doubt about its status. Doubtful trees were then recorded as "suspects" for re-inspection and/or branch sampling for laboratory culture and positive identification of the disease. If the suspect tree was confirmed to be diseased, it was then assigned a number which was recorded with all other collected data on a Survey Sheet (Appendix II, Report O-X-283). One disadvantage of this system was that problems in communication arose between the chief scout and scouting crew--probably because the Job Corps Survey Crew and the CSB chief scout were working independently for different government departments. This communication problem was not recognized until it was too late in the season to change the system.

These general survey procedures have developed and improved over the years to provide a more efficient scouting program. The key to its effectiveness, however, appears to be intensive coverage by well trained scouts. In Sault Ste. Marie this effectiveness has been shown by a drop in the number of diseased trees missed over the past 2 years. Full results of this survey method will be known by mid-summer of 1980.

SANITATION

The cost of the city's 1978 sanitation program was $49,908.00. This included removal, disease scouting, trimming and the city's share of the costs of chemical injection. The cost is lower than that of the previous year and generally reflects a 25% decrease in the number of trees removed. Work breakdown was as follows:

(a) removals by contract and city crews - 740 trees (from 1977 survey) (See Table 8).

(b) trimming by city crews - 21 trees

(c) injection by city crews - 83 trees

The total spent on Dutch elm disease control in the 11-year period between 1968 and 1978 is $293,159.00.

Removal of infected trees in the Sault Ste. Marie area is generally carried out during the fall and winter months on or before 15 April of the following year to prevent beetles from spreading. The procedures for the program are detailed in the 1977 report (Report O-X-283). The only changes from the previous winter's program were as follows:

(a) One less equipment operator was used in the city removal crew. This was due to a reduction in the amount of heavy equipment required to remove many of the smaller diameter trees now left within the control area.

(b) A notice was printed in the local newspaper warning the public against keeping recently dead or dying elmwood within the control area for firewood or other uses. The notice referred to the local bylaw against such use unless permission is obtained from the Parks Department. Periodic inspections in many areas showed that the notice had the desired effect.

Table 8. Elm disease program losses within control area[a], 1968-1978

Year	No. of removals[b]	Percent 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	1001	12.5
1977	740	9.3
1978	269	3.4
Total	4424	55.3

[a] Based on an estimated total of 8,000 high-value elms within the control area (Low-value, generally small diameter trees in uninhabited woodlots and ravines are not included.)

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

Removal costs per tree in 1978 were as follows:

Municipal trees by city forces	-	$169.00 per tree
Private trees by city forces (generally residential, requiring piecemeal removal)	-	$ 92.00 per tree
Private trees by contractors (generally woodlot and ravine trees)	-	$ 27.45 per tree

The cost of removing diseased trees from private property by both city forces and private contractors was lower in 1978 than in 1977, probably because the trees removed were smaller in diameter.

ELM PLANTING AND ESTABLISHMENT

Elms are among the most suitable trees for city planting. They can be used in areas where root growth is restricted, and they are considered a superior tree because of their resistance to air pollution. City elm plantings have been minimal since 1968 because of the efforts put into Dutch elm disease control. Only four native *Ulmus americana* trees have been planted under city supervision in the disease control area since 1976. Six young elms have also been transferred to the city nursery for future transplanting. All are still alive and well established.

Ten first-year grafts of "urban elm", a new variety of Siberian elm (*Ulmus pumila*), were received in early spring, 1977 from the United States Department of Agriculture research laboratory in Delaware, Ohio for hardiness testing in Climatic Zone 4b and resistance to Dutch elm disease. That year one tree died by September; the remainder put on 30 cm to 90 cm of new growth. In 1978 no mortality occurred but only 8 to 30 cm of new growth was observed by late summer. All seedlings showed late bud growth in the spring as well as poor form and vigor on the current year's growth.

During 1978 investigative research was started by the Great Lakes Forest Research Centre in Sault Ste. Marie to test two new elm selections from research stations in western Canada. One selection from Morden, Manitoba, is known as the "Jacan" elm; the other from Indian Head, Saskatchewan, is called the "Thomson" elm. Both trees originated as seedlings of Japanese elms (*Ulmus japonica*) and are readily propagated by budding or grafting on seedling understock of Siberian elm (*Ulmus pumila*). The trees were originally selected on the basis of form, superior vigor and hardiness at the western stations. Inoculation tests conducted in Sault Ste. Marie have shown both introductions resistant to Dutch elm disease.

Contact with service clubs on the 1977 recommendation to plant elms in low hazard areas of the city elicited some interest from one group. However, no plantings were carried out in 1978.

ELM WOOD UTILIZATION

Elm is a valuable wood species for lumber and veneer, and even for mulch when it is chipped. Investigation of better utilization methods has been recommended as part of the integrated program since its inception; however, demands on time and human resources have prevented work in this area. Where possible in 1978 the city continued with utilization methods that have proven successful since 1973. These are:

(a) authorizing removal contractors to market logs if they reduce tender costs

(b) instructing the contractor to save marketable wood which the city sells by tender to the highest local bidder

(c) stockpiling debarked wood for park playground construction (The wood is excellent for this purpose because of its strength and rot resistance.)

(d) chipping limbwood up to 15 cm in diameter during removal operations (The chips are stockpiled and used for mulching shrub beds and under playground equipment in place of sand to reduce park maintenance labor.)

These methods utilize some wood. However, problems such as high handling costs, lack of markets for sale of wood, strict control until material is out of the sanitation control area, citizens stealing material for firewood, and possible attraction of bark beetles to fresh wood chips all suggest the need for further research into the economical marketing of removed elms or better utilization of the wood, so that costs of municipal sanitation programs can be reduced.

RECOMMENDATIONS FOR 1979 INTEGRATED PROGRAM

(1) Because of communication problems, diseased elms are still being missed; therefore the survey should be carried out by a chief scout and a fully trained crew, working under one authority. In addition, the ultimate responsibility for all of the data collected should rest with a single individual.

(2) Research should be undertaken to investigate the attractiveness of elm wood chip mulch to the native elm bark beetle. It would be difficult to conduct research of this type in Sault Ste. Marie as there is no significant native beetle population. Therefore, this work should be carried out elsewhere.

(3) Test plantings of existing disease-resistant elms should be carried out either by local service clubs or by the municipality. Further research should be conducted into the development of additional varieties of elms that are both disease resistant and hardy in Sault Ste. Marie.

(4) Since a portion of the injection work in 1978 was satisfactorily carried out by a private contractor, an attempt should be made to contract out the majority of the elm injections.

(5) An effort should be made, through increased publicity, to increase community awareness of the success of the Dutch elm disease control program.

(6) An improved system of labelling elms should be developed. The use of photographic identification techniques should be investigated.

(7) An effort should be made to develop an evaluation system that would classify each selected high-value elm according to its suitability for the various treatment methods available.

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