Three Decades of Dutch Elm Disease in Fredericton, N.B.

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Abstract

The City of Fredericton, New Brunswick, has saved 70% of its elms since Dutch elm disease was first found here in 1961, while most elms in surrounding areas have been destroyed. This report details the City's efforts to control the disease over the past 30 years. Part I deals with the biological and historical background of the disease and its carrier, and the City's control measures. Part II presents, through text, tables, and figures, all aspects of Fredericton's Dutch elm disease management program — surveys, sanitation, insecticides, trap trees, tree injection, implants, and the planting program. Part III reports the results of an evaluation — bark beetle population studies, tree losses, and the cost of the program. Part IV is a short version of Fredericton's Dutch elm disease story through the various periods occurring over the three decades. Of the original elm population, 29.9% was lost to the disease, leaving the City with about 3,000 elms within the historical City center — about 1,000 of these high-value street trees. Through a vigorous planting program — an average of over 700 trees have been planted annually since 1974 — the old monoculture is being rejuvenated, while the character of the City of Stately Elms has been retained. The report contains 13 tables, 5 figures, and over 15 photographs.

Résumé

Depuis qu'on y a décelé pour la première fois la maladie hollandaise de l'orme, en 1961, la ville de Fredericton, au Nouveau-Brunswick, a réussi à sauver 70 p. 100 de ses ormes, tandis que la plupart des ormes des régions environnantes ont été détruits. Le présent rapport fait état des mesures prises par la ville au cours des trente dernières années pour lutter contre la maladie. Dans la première partie, on traite des aspects biologiques et historiques de la maladie et de son facteur, ainsi que des mesures de gestion prises par les autorités municipales. Dans la partie II, on explique, à l'aide de tableaux et de graphiques, tous les aspects du programme de gestion contre la maladie hollandaise de l'orme à Fredericton, c.-à-d. les levés, l'assainissement, les insecticides employés, les arbres pièges, l'injection des arbres, les implants et la plantation d'arbres. La partie III rend compte de l'évaluation du programme, notamment des études sur les populations de scolytes de l'écorce de l'orme, des pertes d'arbres et du coût du programme. La partie IV fait l'historique de la maladie hollandaise de l'orme à Fredericton à divers moments au cours de ces trois décennies. De la quantité initiale d'ormes, 29,9 p. 100 sont morts des suites de la maladie; il n'en reste donc plus qu'environ 3 000 au coeur de cette ville historique, dont environ 1 000 qui ont une grande valeur. Grâce à un programme soutenu de plantation — plus de 700 nouveaux arbres ont été plantés en moyenne chaque année depuis 1974 — on renouvelle et on diversifie la forêt urbaine tout en parvenant à préserver une partie des célèbres ormes majestueux de la ville. Le présent rapport contient 13 tableaux, 5 figures et plus de 15 photographies.

This report is dedicated to:

Mr. C.C. (Charlie) Smith

who has 'served' for 35 years: he sampled the first diseased elm tree in Fredericton; he has been scout, trainer, chairman, advisor, consultant, and advocate; and he has been involved on more fronts in the battle against Dutch elm disease in the Maritimes, and specifically in Fredericton, than anyone else.

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Three Decades of Dutch Elm Disease in Fredericton, N.B.

Introduction

The mere mention of Dutch elm disease conjures up mental pictures of cities and towns with hundreds of dead and dying trees towering over or falling on houses, vehicles, and people, the sound of chain saws, of huge branches crashing to the ground, the sight of treeless streets simmering in the summer heat or being swept clean by unimpeded winter winds — and of municipal councils desperately trying to balance budgets upset by the enormous cost of removing the remnants left behind by this ravaging tree killer.

Yet, in other places, citizens and tourists stroll in the shade under a canopy of magnificent elms; enjoy a backyard picnic or watch children play, protected from the sun's harmful ultraviolet rays; enjoy the soothing breeze in the evening before retiring to a house kept cool during the day by the protective foliage. The City of Fredericton is one of those places.

Some 30 years ago, in 1961, two elm trees in Fredericton were found to be infected by Dutch elm disease. The arrival of this dreaded tree killer was not unexpected. Years earlier, on good advice, City Council initiated a program of management designed to prevent such catastrophes as the destruction of the elms. This tree species is integral to the beauty of the "City of Stately Elms," the capital of New Brunswick.

After 30 years of consistent commitment to the management program by successive municipal governments, the City's old core is still hidden beneath a canopy of century-old elms, and a young stand, comprising a variety of species, is growing to replace them when necessary. The City saved 70% of its original elm population from the disease, but surrounding areas are almost devoid of large elm trees.

This report has several purposes,among them to take stock of what has been done in the management program over the past 30 years: how it was done, at what cost, and with what results. Its purpose is also to present this information to: the citizens of Fredericton, so they can judge how their heritage, a unique urban forest, has been managed; to the organizations that supported and participated in the program, to tell them how their investment — time, effort, money — has been spent; other communities facing the demise of their elms, because they may find some of this information applicable to their circumstances; and the scientific community, as a chapter on how one city handled Dutch elm disease and with what success.

The main purpose is to bring all available information together, not to evaluate success or to justify action. Nor is this report meant as a textbook on the disease or as a recipe for its control.

This is a report on how Fredericton coped with Dutch elm disease from its arrival in the City until 1990. It is based on studies carried out by staff of Natural Resources Canada and on records in the City Engineer's office. The story of Fredericton's fight against Dutch elm disease has been told before: 20 years after the arrival of the disease (Magasi *et al.*, 1981) and 25 years after (Magasi *et al.*, 1985) in conjunction with the City's bicentennial celebrations. Now, after 30 years, we have drawn freely from those reports and have included most of the information presented in them, as well as presenting the results since then.

Readers may find this publication somewhat repetitious because the various sections within the report are intended to be autonomous.

Part I
Biological and Historical Background

The Disease and its Carrier

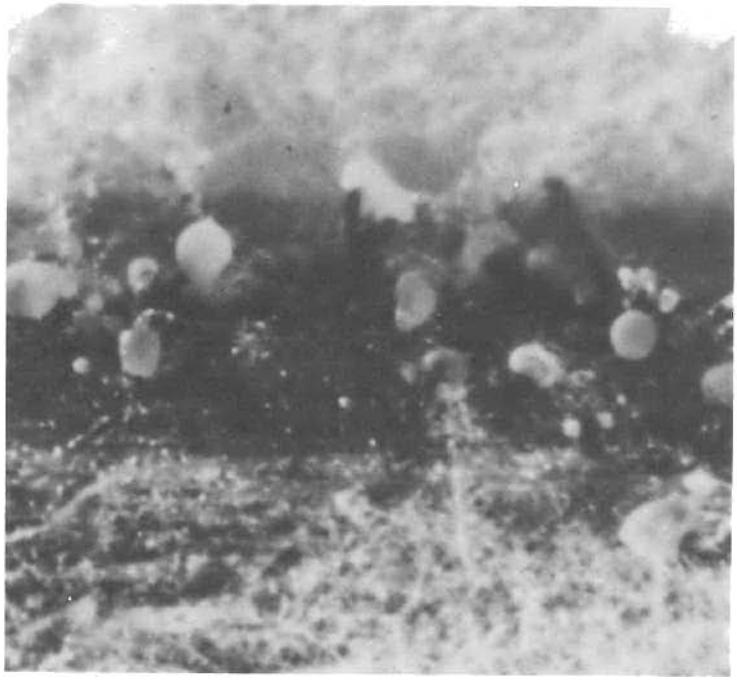
Dutch elm disease is caused by a fungus (*Ceratocystis ulmi* (Buism.) C. Moreau) which, when introduced into elms, interferes with the normal physiological processes of the tree. The leaves wilt, turn yellow, then brown, and the infected branch dies. The fungus travels quickly in the water-conducting system and spreads to other parts of the tree within a short time. The tree may die within a year or may 'hang-on' for a number of years before it succumbs to the disease.

Elm tree affected by Dutch elm disease

The native elm bark beetle (*Hylurgopinus rufipes* (Eichh.))

The fungus, in Fredericton, is introduced into the tree by the native elm bark beetle (*Hylurgopinus rufipes* (Eichh.)). The beetles breed in and under the bark of dying or newly dead trees. When this brood tree is infected, minute, sticky structures (spores) of the fungus stick to and are carried by the beetles to healthy trees. Beetles feeding on twigs of healthy trees open a way to the water-conducting vessels, and the spores enter the tree and infect it with the fatal disease.

Fungus fruiting bodies



Some beetles spend the winter burrowing into the thick bark of the tree trunk and large branches. If these beetles carry the fungus, it multiplies in the beetles' overwintering

chamber, covering the beetle when it emerges in the spring. The large number of spores carried by these beetles spread the infection rapidly when the insects start feeding.

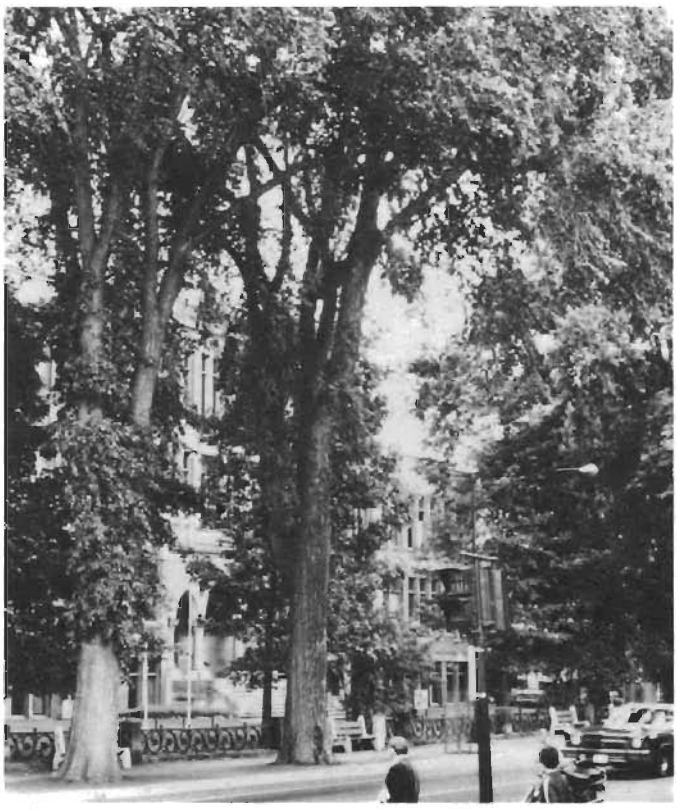
The European elm bark beetle (*Scolytus multistriatus* (Marsh.)), the main carrier in other parts of the continent, is not a factor in spreading the disease in Fredericton. Single individuals were found in traps only in 1986 and 1987 (see Table 8).

Almost all methods of slowing down the spread of the disease are aimed at this special relationship between the fungus and its carrier. Lowering the number of beetles and preventing them from carrying the fungus has been the basic goal of most Dutch elm disease management programs. Newer methods aim directly at the fungus but, to date, these have only been used on a limited scale in Fredericton.

Fredericton and its Elms

The City of Fredericton, in the Saint John River Valley, was settled by the United Empire Loyalists in 1783 and was declared a city in 1848. It was surrounded by forested areas in which white elm (*Ulmus americana*) was a predominant species.

The first elm trees in the City were planted by the British garrison around 1810. Another major planting was done by civic authorities between 1883 and 1887 and again, in some of the newer parts of the city, shortly after the Second World War. Many of the original elms, now 100 to 170 years old, are still standing, some of them 32 m (105 ft) tall, and trees with diameters of 100-180 cm (3-6 ft) are not uncommon.



A view of some of the original elms on Queen Street in Fredericton

Our ancestors were aware of the beauty of this magnificent tree and of the benefits of the shade it provides. However, they created a single species area, an almost even-aged monoculture, susceptible to insect and disease attacks, necessitating remedial action on a large scale if catastrophes were to be avoided.

Forewarned by the Forest Biology Laboratory (predecessor of Natural Resources Canada) in the 1930s, City Council became interested in the care of the shade trees. During an outbreak of the fall cankerworm (*Alsophila pometaria* (Harr.)) severe defoliation of the elms was prevented by a thorough protection program. Cooperation between the City and the federal establishment has continued throughout the years.

In 1973, amalgamation of Fredericton with the villages of Barker's Point, Lincoln, Marysville, Nashwaaksis, and Silverwood more than doubled the area of the City. This created a new situation in tree care that affects some operations to the present day.

The City's elm trees have been under increasing stress of various types through the years. Like all urban trees, elms are also subjected to ever-increasing people pressure, which includes, among many other factors, such things as increased pollution, paved-over root systems, roots severed during construction, *etc.* Periodic insect outbreaks create another type of stress. Fall cankerworm, forest tent caterpillar (*Malacosoma disstria* Hbn.), elm leaf aphids (*Tinocallus ulmifolii* (Monell)) and, in the last decade, two serious outbreaks of the elm leaf beetle (*Pyrrhalta luteola* (Mill.)) have taken their toll on the aging elm tree population. Growth has slowed down and twig- and branch-dieback is obvious on many trees. Removal of decadent trees, to reduce hazards to life and property, has been an on-going activity of the City's Parks and Trees Division. In spite of all this, the elms endure.

The Fredericton Tree Commission

After the Second World War, a tree advisory committee was appointed and, in 1952, a City by-law established a permanent Tree Commission. The members are volunteer taxpayers concerned with and interested in trees (Appendix I). Many of them deal with some aspect of tree care and protection in their profession. The City is represented on the Commission by a councillor, the City Engineer, and the Superintendent of Parks and Trees.

The duties of the Commission originally were:

> "(a) to formulate plans for and to supervise the planting, setting out, maintenance and care of trees on the streets and lands of the City;
> (b) to protect trees within the City from injury or destruction by insect pests or disease and to provide for the spraying of trees with insecticides and fungicides;
> (c) to encourage proper pruning, protection, and replacing of all trees within the City;
> (d) to enter upon any lands within the City for the purpose of inspecting trees to determine whether they are hazardous to persons or property or

affected by disease or insect infestation;
(e) to determine whether a tree or limb thereof within the City is hazardous to persons or property or so affected by disease or insect infestation as to endanger the life or health of other trees;
(f) to order the removal of a tree or limb found to be hazardous to persons or property or so affected by disease or insect infestation as to endanger the life or health of other trees."
By-law 412 of the City of Fredericton.

One of the most important provisions of the original by-law has been the authority to enter private land and cut trees at the expense of the City. This ensures prompt removal of diseased trees which otherwise might be delayed by the reluctance of the owner. Stand protection has been one of the basic principles from the beginning.

The duties of the Tree Commission have expanded through the years. The Commission realized that a more concentrated effort was needed to carry out the overall tree program than its members (mostly Mr. C.C. Smith, a Natural Resources Canada employee) were able to provide. On their recommendation, City Council agreed to hire a graduate of the Maritime Forest Ranger School as Supervisor of Parks and Trees. This action led to the establishment of the Parks and Trees Division, under the direction of the City Engineer in 1967. The working relationship between the Division and its advisory body has been excellent. It has allowed the Tree Commission to expand its activities into other areas of the Division's work.

Tree Commission members often collaborate with City staff, individually or in small groups in subcommittees, providing their expertise to projects such as the restoration of the 'Old Burying Ground' where the original Loyalists and other early settlers of Fredericton rest; public lecture series on trees, shrubs, and other related subjects; insect and disease problems other than Dutch elm disease; beautification of parks and other public places, *etc.*

The Tree Commission also acts as a guardian, protecting against needless loss of healthy trees to street construction or to the whims of those who wish to cut trees without sound reasons. The Commission, being a non-political, impartial body, can strongly advise against such actions. This fact has proved useful on many occasions and has saved many healthy trees from needless cutting.

However, the Tree Commission has never lost sight of its original purpose — the care of Fredericton's trees. Through their vigilance and due to the respect in which they are held by both the public and City Council, funds needed to carry out an excellent tree program have never been threatened.

The Parks and Trees Division in Fredericton

The Parks and Trees Division was established in 1967 with the appointment of a Supervisor of Parks and Trees, attached to the City Engineer's office. Continuity was provided by the close working relationship between the Supervisor and the Tree Commission member who previously carried most of the burden and who, upon retirement from Natu-

ral Resources Canada, continued as a consultant to the City for the next 20 years. All tree work in Fredericton is now carried out by employees of the Division.

In 1973, the City became much larger and faced a situation of uneven quality of tree care in the newly amalgamated areas. The supervisor was elevated to the rank of Superintendent and, since 1981, more trained staff have been hired, including graduates of the Maritime Forest Ranger School, horticulturists, and a graduate Forester, to assist with the increased workload. Staff members are trained and employed year round, providing a continuity of skilled labor, which in turn increases effectiveness and safety and reduces long-term costs.

Tree climbers are basic to the tree removal program. Fredericton employs two of these highly specialized craftsmen. They move about in the trees with ease and skillfully lower branches on ropes from over houses and wires, to the amazement of tourists from areas where bucket trucks (cherry pickers) are the norm.

Fredericton tree climber at work

Each climber is supported by a ground crew of two and the two teams are backed up by a support crew of loader, chipper, truck driver, and stump grinder operator. It takes anywhere from a few minutes to 2-3 days to remove a tree, depending on its size, shape, location, and condition. Tree removal procedures and a detailed analysis of time and equipment needed for different types of trees can be found in a manual by Van Sickle and Urquhart (1974).

The decision by the City in 1990 to purchase an 18-m aerial lift (bucket truck) to do some of the work, mainly the pruning of 'hard-to-get' trees in high traffic areas, and much of the sampling, was made to take the pressure off the climbers (who are aging along with the trees they have cared for). Replacements, requiring special skills, are not readily available.

Dutch Elm Disease in Central New Brunswick

Dutch elm disease was first discovered in North America in Ohio in 1930; in Canada (Quebec) in 1944 (Pomerleau 1964); and in New Brunswick (Woodstock) in 1957 (Davidson and Newell 1957). By 1961, the disease was well established in the Saint John River Valley from Grand Falls to about 50 km south of Fredericton. It was first found at Kingsclear in 1958, at Durham Bridge and Upper Lincoln in 1959, in Marysville, Lower St. Mary's, and pre-amalgamated Fredericton in 1961, at Barker's Point, New Maryland, and Lower Lincoln in 1962, and in Nashwaaksis in 1965.

Many trees were infected and died. Ten years after the disease was found in New Brunswick, the incidence of infected trees, expressed as a percentage of the total number of living trees, had reached 9% in York County, 13% in Sunbury County, 30% in Victoria County, and 45% in Carleton County (Forbes *et al.* 1967). In four rural check areas, established in 1970 within 60 km of Fredericton (Van Sickle and Sterner 1976), over 90% of the original elm tree population was lost to the disease within 7 years (Table 1).

Table 1. Losses to Dutch elm disease in the intensification study areas.

Year	Nasonworth		Nashwaak Bridge		Scovil		Welsford	
Elm population in 1970	84		81		298		115	
Dead at establishment	1		1		0		4	
	Trees lost	Accumulated %	Trees lost	Accumulated %	Trees lost	Accumulated %	Trees lost	Accumulated %
1970	3	3.6	2	2.5	13	4.4	3	2.6
1971	0	3.6	4	7.4	12	8.4	1	3.5
1972	0	3.6	11	21.0	67	30.8	6	8.7
1973	11	16.7	9	33.8	78	56.9	12	19.1
1974	14	33.3	20	59.7	55	75.5	21	37.4
1975	24	61.9	20	88.0	plot cut		33	66.1
1976	23	89.3	6	97.3			16	80.0
1977	6	96.4	0	97.3			13	91.3
1978	terminated		terminated				3	93.9
1979							terminated	

Control or Management

The Dutch elm disease control program in Fredericton began in 1952 with the appointment of the Tree Commission, 9 years before the first diseased elm tree was found in the City. In the context of this report, 'control' means the regulation or management of the disease; it is not used to mean the eradication of the disease. Only the naive would surmise that Dutch elm disease can be entirely eliminated from Fredericton (short of eliminating all elm trees) but, by managing the disease, the City should be able to keep tree losses down.

Part II
Dutch Elm Disease Management in Fredericton

Dutch Elm Disease in Fredericton

The first two infected trees in the City were found in 1961, one on Odell Avenue, the other on Lincoln Road. They were promptly removed. In the years that followed, the number of trees removed because of Dutch elm disease varied from year to year, but the number gradually increased until 1980. After that, the infection rate declined sharply and, by 1984, settled down to about 1% per year.

Almost 3,800 elm trees were infected in pre-amalgamated Fredericton between the arrival of the disease and 1990. This figure includes trees of all sizes and quality, from planted street and backyard giants to small wild ones growing in gullies, along brooks and railroad lines, on farms, and other open spaces. Thus, it represents all infected trees that were physically removed and destroyed by the City.

The communities surrounding pre-amalgamated Fredericton took different approaches to their Dutch elm disease situation and there are few reliable figures available on losses. In the early years of Dutch elm disease, the New Brunswick Department of Natural Resources and Energy (NBDNRE) assisted small communities by removing diseased trees, in an effort to lessen the hazard. According to Smith and Forbes (1968), the number of diseased trees removed by NBDNRE between 1958 and 1967 was:

Lincoln	17
Silverwood-Woodstock Road	1
Nashwaaksis	30
Marysville	98
Barkers Point	6
Lower St. Marys	11

After amalgamation in 1973, an accelerated tree cutting program in these areas 'cleaned up' diseased, dying, decadent, and damaged trees to bring the level of general health of trees closer to the standard of 'old' Fredericton.

Methods for Managing Dutch Elm Disease in Fredericton

1. Surveys

Any attempt at controlling the disease must be based on continuous, systematic surveillance. In Fredericton, regular surveys by qualified personnel are carried out from mid-June to about mid-September when autumn leaf discoloration interferes with recognition of disease symptoms. All parts of the City are surveyed several times each summer. Infected trees are marked for cutting. The location of the tree, its size, and classification as to ownership are recorded. Until 1977, branch samples were taken from all suspect trees and were cultured by pathologists at Natural Resources Canada. Routine culturing was discontinued because of the extremely high agreement between field and laboratory identifications, due to the competence of the City's surveillance people.

Although routine culturing was discontinued, suspect trees are still cultured occasionally when the situation warrants, such as in the case of trees of high historical or aesthetic value or trees that are the subject of controversy between private owners and city crews.

2. Sanitation

Sanitation, the removal of tree material suitable for the elm bark beetle as breeding sites, reduces the population of the carrier. The removal of infected tree material prevents beetles from breeding in diseased trees and picking up spores of the fungus. Although there are other management methods, the City of Fredericton has always believed, and is firmly convinced, that ***the cornerstone of any Dutch elm disease management program must be a consistent sanitation program***. There are several aspects of such a program.

2.a. *Preventive pruning* is the consistent and systematic removal of dead branches from healthy trees to eliminate breeding material. In Fredericton, starting in 1952, all elm trees were pruned. Most trees were pruned at least twice and some three or four times between 1952 and 1967 (Smith and Forbes 1968). With the increasing workload of tree removal in the late 1960s and early 1970s, the number of elm trees pruned has decreased and has been confined mostly to City-owned trees and to those that constituted a hazard. For a number of years, trees were pruned on an "as time permits" basis. Recently, with little effort needed for tree removal, the regular pruning program has resumed and several thousand trees — of all tree species — are pruned annually. Sanitation pruning of City-owned elm trees continues, but most trees are pruned for other reasons, such as interference with wires, with clearance and visibility for pedestrian and vehicular traffic, hazards, *etc.* and, of course, to help them attain the desired shape appropriate to the growing space.

2.b. *Preventive tree removal* — Decadent, but not diseased, trees with numerous dead branches are also removed to destroy elm bark beetle breeding material. In Fredericton, about 500 decadent elm trees were removed between 1952 and 1967, most of them before 1961. Table 2 lists the numbers of elm trees removed for reasons other than Dutch elm disease in pre-amalgamated Fredericton (Fig. 1), for which reliable figures are

available. Not all of these trees were decadent. Some were removed for reasons such as traffic obstruction at stop signs, street widening, danger to property, *etc.*

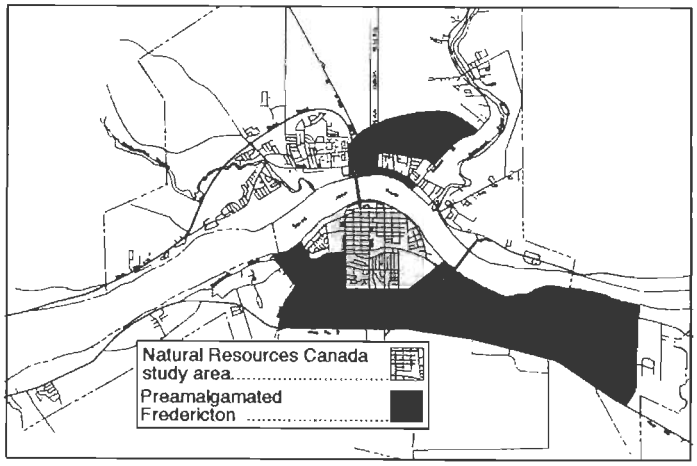


Figure 1. The Greater Fredericton area.

Table 2. Non-diseased elm trees removed in pre-amalgamated Fredericton 1967-1990.

	Trees removed	
Year	Year	Accumulated
1967	45	45
1968	85	130
1969	43	173
1970	46	219
1971	49	268
1972	69	337
1973	42	379
1974	67	446
1975	69	515
1976	16	531
1977	12	543
1978	22	565
1979	60	625
1980	58	683
1981	43	726
1982	8	734
1983	37	771
1984	14	785
1985	11	796
1986	11	807
1987	6	813
1988	16	829
1989	10	839
1990	7	846

2.c. *Removal of infected trees* — Dying and newly dead trees give off an odor that attracts the beetles; these trees provide ideal breeding sites. Beetles contaminated with the fungus emerge from diseased trees, fly to nearby healthy trees to feed, and spread the disease. A single beetle-infested diseased elm tree can became the center of infection in an area from which the disease quickly spreads. The prompt removal of infected trees is an imperative first step in slowing down the spread of Dutch elm disease. There is no substitute for this aspect of sanitation in any disease-management program. In Fredericton, infected elm trees are removed as soon as feasible but definitely before the beginning of May of the year following infection. This date is important because broods must be eliminated before the beetles start flying in the spring. The numbers of infected elm trees removed from the study area each year and from pre-amalgamated Fredericton are listed in Table 3.

Table 3. Elm trees lost to Dutch elm disease in Fredericton 1961-1990

Year	Study area	Pre-amalgamated Fredericton
1961	1	2
1962	0	2
1963	0	1
1964	5	14
1965	4	11
1966	6	18
1967	1	16
1968	11	33
1969	11	23
1970	35	49
1971	42	57
1972	37	62
1973	64	89
1974	101	131
1975	122	144
1976	253	270
1977	163	408
1978	180	276
1979	355	513
1980	374	514
1981	302	411
1982	188	215
1983	127	179
1984	59	64
1985	59	71
1986	33	48
1987	31	49
1988	36	39
1989	23	47
1990	25	28

The 'catch up' cutting program in the newly amalgamated areas is summarized in Table 4. Although elms other than those infected were cut from 1973 to 1980, most of the trees were dead or dying as a result of Dutch elm disease. Most were wild trees growing as a result of natural regeneration. The Province of New Brunswick, through amalgamation grants, and the federal government, through winter works programs, assisted in these cutting operations.

Table 4. Elm trees cut in greater Fredericton as part of the Dutch elm disease program, 1973-1990

Year	Pre-amalgamated Fredericton	Lincoln	Silverwood-Woodstock Road	Nashwaaksis	Marysville	Barkers Point-Lower St. Marys	Total
1973	89	69	385	180	91	6	820
1974	398	42	542	126	248	44	1400
1975	271	71	145	494	55	31	1067
1976	418	3	248	3	13	8	693
1977	743	6	9	83	15	20	876
1978	736	7	124	2251	15	20	876
1979	1026	6	195	371	703	280	2581
1980	514	-	314	88	21	198	1135
1981	411	-	39	66	21	39	576
1982	215	10	16	45	11	2	299
1983	179	2	10	31	5	15	242
1984	64	-	27	13	6	11	121
1985	71	-	6	2	2	1	82
1986	48	4	3	2	4	-	61
1987	49	2	13	4	13	1	82
1988	39	-	6	1	8	4	58
1989	47	-	4	17	10	-	78
1990	28	4	5	9	12	-	58
Totals	5346	226	2091	3786	1253	707	13409

Removal of infected elm trees in Fredericton

In the winter of 1978-79, some areas where most elm trees were dead or dying from Dutch elm disease were clear-cut of all elms (Fig. 2). This was done during the winter, when bark beetles were in the brood trees, to eliminate the high elm bark beetle populations adjacent to healthy areas. Again, most of the work was along rivers, brooks, and other areas of natural regeneration.

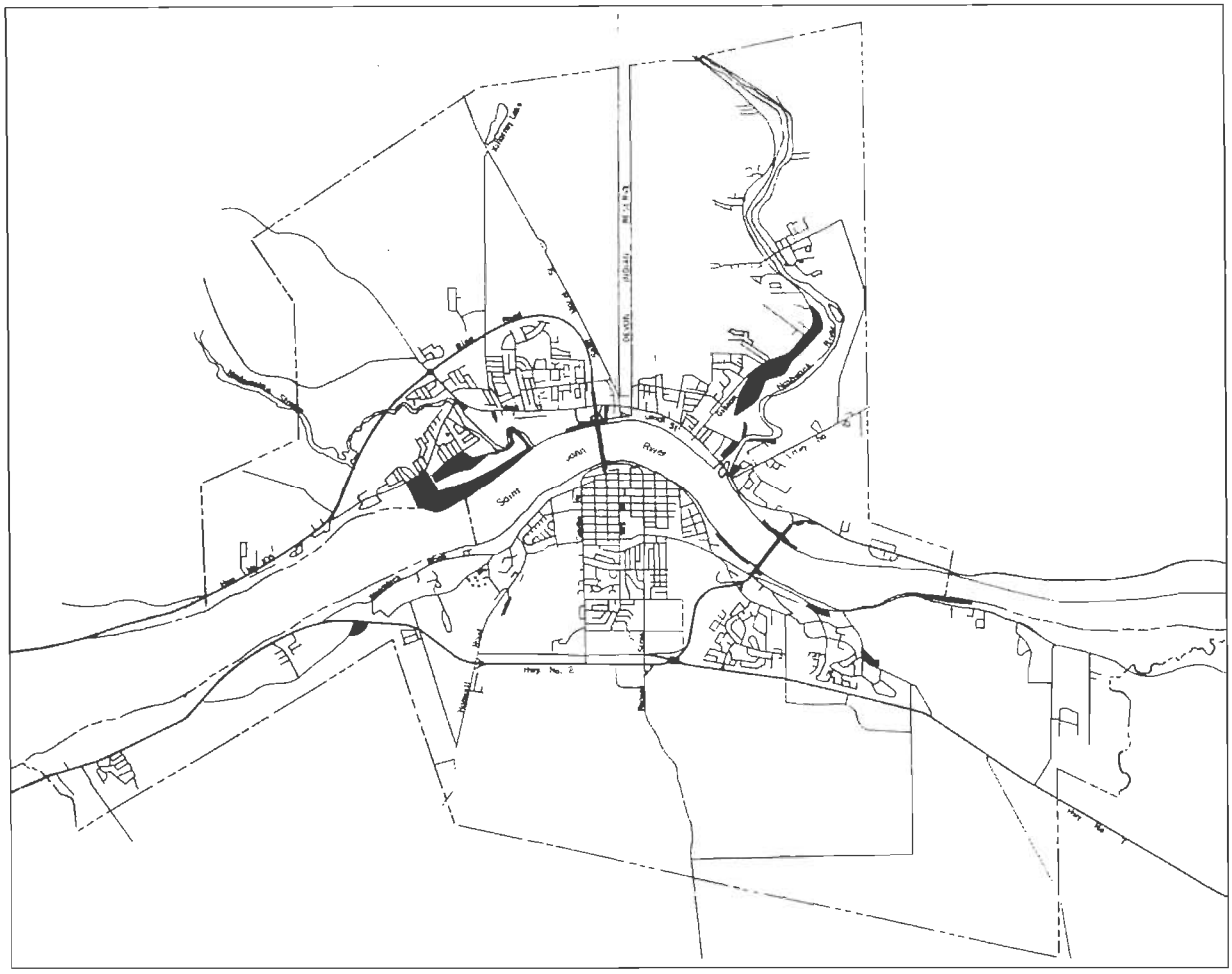


Figure 2. High infection areas clear cut of elm in Greater Fredericton in winter 1978-1979.

2.d. *Burial and burning* — All elm material suitable for bark beetle breeding, whether infested or not, must be disposed of. In Fredericton, branches and tree trunks are buried under about 50 cm of soil. Elm material from clear-cutting operations during the winter months is burned at the site. When Dutch elm disease spread and intensified in New Brunswick, the City started selling elm logs to a hardwood pulp mill in 1973 to reduce the cost of the program. This practice was discontinued after 1984, however, mostly because the quantity of the material cut no longer warranted contracts. In 1980, the City acquired a brush chipper to reduce the transportation cost of light but bulky twigs and branches.

Elm logs ready for disposal

Brush chipper used by the City of Fredericton

2.e. *Stump removal* — The stump of an elm tree with the bark intact is no less attractive to the bark beetles as a breeding site than the rest of the tree. The freshly cut stump may actually attract beetles by giving off the characteristic odor (Euale *et al.* 1978) of a dead or dying tree. Stumps are also unsightly and interfere with snow removal. In Fredericton, all stumps are removed with the aid of the City-owned stump grinder, shortly after the tree is felled. The stump is ground to about 10 cm below the surface and the hole is filled with soil and seeded. This procedure improves the aesthetic appearance of the area and removes the attraction for the beetles.

Removing a stump using the stump grinder

2.f. *Debarking* — If the stump cannot be ground immediately, it is debarked manually. A debarked elm log cannot be used by bark beetles for breeding and, as such, poses no threat.

Debarked elm stump

All aspects of the sanitation program have been practised in Fredericton since long before Dutch elm disease arrived in the City and will continue as the basis of the tree management program. Especially important is the prompt removal of infected trees.

3. Insecticides

Insecticides have a legitimate role in the management of Dutch elm disease to lower elm bark beetle populations. They have been used in Fredericton, from time to time, against a variety of insects, as recently as 1975. Arsenate of lead and pyrethrum were used first, DDT was applied several times before 1972, malathion was used in 1973 and 1974, methoxychlor in 1975, and chlorpyrifos until 1985.

The City has kept pace with growing environmental awareness. Insecticides were used as a last resort, only when deemed absolutely necessary, and were used with utmost care. The needs were reviewed by the Tree Commission; the effectiveness of the insecticide monitored in cooperation with Natural Resources Canada; and use followed the recommendations of the New Brunswick Pesticide Advisory Board, which reviewed and authorized applications. For Dutch elm disease management, whole-tree spraying has been limited to high-value trees in uninhabited areas, like parks, and carried out in the early morning when there was no wind, and when people were absent. Trunk treatment in residential areas has been carried out with low-pressure equipment to reduce drift. Private trees have not been treated without the owner's permission. The support and cooperation of the public has been heartwarming to those responsible for tree care.

Insecticide spraying

There has been no spraying related to Dutch elm disease in Fredericton since 1985.

3.a. *DDT* — was used to kill elm bark beetles in Fredericton from 1961 to 1963. Healthy elm trees in the vicinity of infected trees (within 330-m radius) were sprayed during dormancy with a 12.5% water emulsion of DDT applied by mistblower. All elms on public property around the Cathedral and on University Avenue were sprayed intermittently

between 1957 and 1973 to control fall cankerworm. This must have had an effect on the elm bark beetles as well.

3.b. *Methoxychlor* — Because of the rapid increase in infection levels in the mid-1970s, Fredericton decided to supplement the sanitation program by using chemicals to reduce elm bark beetle numbers. At the time, methoxychlor was the only insecticide registered against the elm bark beetle in Canada.

i) *Whole-tree spray with methoxychlor.* To prevent feeding by elm bark beetles, boles and crowns of 500 elm trees were sprayed in April 1975, with 12% methoxychlor, on the grounds of the Cathedral, the Parliament buildings, and Government House, as well as along Brunswick Street and along streets bordered by University Avenue, Alexandra Street, and the Green. Evaluation of the program indicated only a minimal reduction in beetle numbers in the sprayed area (Sterner 1975), while the oil base solution caused damage to vehicles and was difficult to remove from any object.

ii) *Basal trunk spray with methoxychlor.* In August-September 1975, about 3,000 trees were sprayed up to 3 m from the ground, in the same areas as in the spring, to prevent the beetle from overwintering; Wilmot Park, the Old Burying Ground, King Street, and a two-block section on Aberdeen Street, between York and Northumberland streets, were added. This procedure was repeated in late summer of 1976 along George Street between Smythe Street and University Avenue. Research results (Gardiner 1976) indicated that methoxychlor was rather ineffective against the native elm bark beetle. Therefore, the use of this insecticide was discontinued.

3.c. *Chlorpyrifos (Dursban 2E®, Dow Chemical)* — New research has shown Dursban, an insecticide of wide application in areas of habitation, effective in reducing elm bark beetle populations. In 1976 and 1977, Natural Resources Canada participated in a nationwide research project testing Dursban as part of the process for registering the insecticide for use in elm bark beetle control. The work in Fredericton was done under an experimental research permit from Agriculture Canada and also under a permit from the New Brunswick Pesticide Advisory Board (Magasi 1977, Gardiner 1980).

i) *Whole-tree spray with Dursban.* Entire trees were sprayed with 1% Dursban applied by mistblower before bud break to prevent beetles from feeding. In Fredericton, this program was carried out on high-value elm trees between 1977 and 1980 (Table 5). Areas treated involved trees from York Street east to the Railway Bridge along the Green and along Queen Street from 1977 to 1979, with trees in Wilmot Park added in 1980. Some doubts were raised by the results of this program regarding its effectiveness (discussed in Part III.

Table 5. Chlorpyrifos (Dursban 2E®) whole-tree spray program in Fredericton)

	Whole-tree sprayed			Check areas			Difference in percentage
Year	Number	Lost	%	Number	Lost	%	
1977	54	0	—	—	—	—	—
1978	93	5	5.4	—	—	—	—
1979	86	7	8.1	105	15	14.3	6.2
1980	166	17	10.2	105	15	14.3	4.1

ii) *Basal trunk spray with Dursban.* To prevent overwintering of beetles in healthy elms, the lower 3 m of the trunks were treated at the end of the summer. Ideally, Dursban is applied (1% solution) to all trees in an area, rather than to individual trees, because the beetles do not confine their feeding to the trees from which they emerge after overwintering. In Fredericton, this 'ideal' has not always been possible to achieve. The program, as carried out, is summarized in Table 6 and involved at one time or another most elm trees in pre-amalgamated Fredericton.

Table 6. Chlorpyrifos (Dursban 2E®) basal trunk treatment in Fredericton

Year	No. of trees treated	Remarks
1976	3000	All trees in area treated
1977	3500	All trees in area treated
1978	3000	Only city trees treated
1979	2500	Only city trees treated
1980	—	

4. Trap Trees

Dying and recently dead trees emit an odor that attracts elm bark beetles searching for breeding sites. The beetles seek out these trees, enter through the bark, and lay eggs. This habit can be exploited in two ways. Trees killed with certain chemicals attract the beetles (Lanier 1979). In turn, these trees can be treated with an insecticide that will kill the arriving beetles. In the late fall or winter, the tree is removed and destroyed to eliminate developing bark beetles, the offspring of those that were not killed by the insecticide. Because some beetles attracted by the chemical could feed upon surrounding healthy trees and cause infection, trap trees are used in areas of high beetle populations with the idea of retaining and destroying them *in situ.* In Fredericton, the trap tree method has been used only once. The chemical used to kill the tree (in an uninhabited area) was Silverstar 550®.

5. Tree Injection

All the methods described above are directed against the bark beetles rather than the fungus that causes Dutch elm disease. Injection is designed to prevent the fungus from infecting the tree or to stop the fungus from becoming systemic after infection takes place.

A fungicide is injected into the tree through roots, root flare, or the trunk (Kondo 1972). The tree distributes the chemical within its system and when the fungicide comes in contact with the fungus, the latter is either killed or inhibited. Basically, this is the principle of all chemical injection treatments. Its effectiveness depends on the distribution of the chemical within the tree and annual repetition of the treatment.

The fungicide is used both as a preventive and a curative treatment. Although the cost of application has decreased in recent years, it remains sufficiently high for this method to

be used on individual trees only. Injection is not, and never was meant to be, a replacement for sanitation, in spite of the publicity it has received.

Losses due to Dutch elm disease were increasing at an alarming rate during the period preceding 1981. There was concern that injection might be the only method to save some of the high-value trees that the City wished to save at any cost. In 1981, Fredericton arranged training in the proper injection of elm trees for the appropriate staff members. A number of trees were injected over a 2-year period, using either Lignasan® or Arbotec 20®. The injections proved to be successful, as none of the treated trees became infected during the effective period of the chemical.

Disease levels decreased drastically after 1981. The repeated wounding of trees with injection equipment was no longer warranted with infection rates around the 1% level. The injection of healthy trees was discontinued after 2 years and treatment was confined to high-value trees with early symptoms of Dutch elm disease. A number of these trees were injected and the infected limbs were removed. This method also showed some success. Equipment is maintained and kept in readiness should the need to treat trees with early symptoms arise. However, no trees have been injected in Fredericton since 1986.

6. Implants

Small plugs of compressed sawdust, impregnated with inhibitor-producing fungi (BINAB®), were inserted into the water-conducting parts of tree stems. The idea was that, as the plug dissolved the fungal component would produce inhibitors that would prevent the spores of the fungus causing Dutch elm disease from germinating and thus infecting the tree. Several dozen trees were treated. There was no difference between treated and untreated trees, elms in both groups became infected. When diseased trees were dissected, the plugs were found to be dry, intact, and apparently ineffective. The method was not used again after the initial failure.

7. Tree Planting

Dutch elm disease management will not prevent all tree losses. Trees will continue to die from Dutch elm disease and other causes. In Fredericton, our legacy is a beautiful but very old stand of elms and the loss of some or even most of these trees is inevitable. However, Dutch elm disease management is likely to lessen losses, thus giving the City an opportunity to replace the aging urban forest gradually with a mixed stand of vigorous trees, without the aesthetic and financial upheaval of a major tree-cutting program.

Fredericton is also a growing city with new housing developments. Tree planting in these areas is based on lessons learned; streets are planted with a mixture of tree species suited to the character of the area. Five varieties of maple, as well as linden, oak, green ash, and white ash are planted, along with a number of varieties of elm (*Ulmus* x Homestead, *Ulmus glabra* "Pendula", *Ulmus* x Pioneer, *Ulmus pumila* "Park Royal"), with varying degrees of resistance to Dutch elm disease, both as replacements and as new plantings. Some white (American) elm is also planted in the historic areas of the City, partly to retain character, and partly to express confidence in the disease management program that will allow "these trees to make it." The Fredericton planting program since

City crew planting trees along roadside

Young tree protected by steel tree guard and sidewalk grate

1974 is summarized in Table 7. In some areas, young trees are protected by steel tree guards and sidewalk grates. These protectors increase citizen awareness and appreciation for trees, and provide a certain attractiveness to the area.

Table 7. Tree planting program in Fredericton since amalgamation

Year	No. of trees planted	Replacement	New Areas
1974	420	99	321
1975	495	100	395
1976	656	458	198
1977	743	184	559
1978	764	183	581
1979	702	58	644
1980	750	279	471
1981	633	118	515
1982	560	97	403
1983	535	110	425
1984	696	124	572
1985	753	159	594
1986	751	163	588
1987	739	171	568
1988	850	150	700
1989	917	185	732
1990	848	235	613

Integrated Approach to Dutch Elm Disease Management

There is no known cure for Dutch elm disease. However, there are methods to fight it, but none presently available can do the job by itself. Each helps to a certain extent and for that reason each should be used, and in an organized, planned manner. Then the results should be cumulative. Fredericton has been using an integrated approach by: setting priorities; monitoring the effect of certain treatments and adjusting the program accordingly; and coordinating treatments and area priorities, *etc.* While standing firmly by the "sanitation first and foremost" principle, Fredericton originally attempted to provide an equal level of service to all areas. However, some areas and some trees in those areas are more valuable than others and have been given special treatment. Recognizing this, 'high-value' trees received the whole-tree spray treatment during the height of the beetle invasion, while others were subjected to injection programs that could not and should not include all elm trees in the City. Other aspects of the disease management are also adjusted to make it a truly planned, integrated program.

Part III
An Evaluation of the Dutch Elm Disease Program

The most logical way to evaluate a program designed to save trees is to examine tree losses. However, before presenting this information for the Fredericton Dutch elm disease management area (the district of historical importance), the results of the elm bark beetle monitoring project are given because most of the methods used in Fredericton are directed against this insect. Monitoring has been conducted jointly by Natural Resources Canada and the City.

Beetle Population Differences in Different Treatment Areas

The Beetle Index - Sticky traps placed about 4 m from the ground around the circumference of selected elm trees are designed to capture elm bark beetles in the fall when they migrate downward to overwinter. The beetle index (Sterner 1976) expresses the number of beetles captured per 10 cm^2 of the trap. Since most beetles are captured in the upper 1 cm of the sticky trap, the index is calculated as the number of beetles per 10 cm of the circumference of the trap. The beetle index is not necessarily an expression of the actual beetle population present on the tree, but has a comparative value between areas in the same year and between years on the same tree. The results of the beetle monitoring program are presented in Table 8. The figures, evaluated annually in the planning of the Dutch elm disease program, show some interesting trends, such as:

1. Beetle populations in the Dutch elm disease management area (DEDMA) were much lower than elsewhere at the beginning of the program and remained very low throughout the period;

2. Populations within the DEDMA were highest at the two traps (3, 5) closest to outside trouble spots until 1980, after which they have been comparable to other areas (*i.e.*, Queen's Square close to the railway line, Government House close to both Nashwaaksis and Woodstock Road);

3. The 1977-78 and 1978-79 winter clear-cutting programs (Fig. 2) drastically and immediately reduced beetle populations in the newly amalgamated areas (7-10), after which populations stabilized at very low levels throughout greater Fredericton;

4. The Nashwaaksis cleanup program did not "drive the beetles into the city," as some feared;

5. Beetle populations in New Maryland, south of Fredericton and with a long history of Dutch elm disease, decreased gradually as most elm trees died and have been comparable with those in the City since the mid-1980s;

6. Beetle populations at Estey Bridge and Cross Creek, north of Fredericton, increased gradually until the early 1980s with the intensification of the disease in those areas, then declined gradually and, by the end of the 1980s, reached levels similar to those in Fredericton a decade earlier, after all elm trees were lost.

Table 8. Beetle index at the native elm bark beetle monitoring stations in the Fredericton area 1976-1990

	Beetle Index												
	DED Management Area					Greater Fredericton					Outside Areas		
Year	1	2	3	4	5	6	7	8	9	10	11	12	13
1976	0.3	0.1	3.6	0.9	0.6	-	-	-	-	-	-	11.5	6.7
1977	0.2	0.7	4.6	0.5	1.6	0.2	-	-	-	300.2	-	18.5	7.5
1978	0.5	0.7	12.2	0.5	2.2	0.6	0	0	0	120.2	-	63.5	12.9
1979	0.2	0.5	5.3	0.3	0.8	0.5	21.7	12.7	276.0[a]	20.0	125.2	25.1	30.5
1980	0.3	0.0	0.5	0.2	1.6	0.3	1.8	1.7	7.8	5.5	53.3	37.7	34.9
1981	0.0	0.0	<0.1	0.0	0.2	0.0	0.0	< 0.1	0.6	1.6	8.9	30.6	18.2
1982	<0.1	<0.1	0.2	<0.1	0.2	<0.1	0.1	<0.1	0.7	1.4	7.8	40.4	24.3
1983	0.0	0.0	0.0	0.0	1.2	<0.1	0.0	<0.1	1.0	1.1	2.3	5.6	8.8
1984	<0.1	0.0	0.1	0.0	<0.1	0.2	<0.1	0.0	0.2	0.0	0.2	8.0	5.2
1985	0.0	-	0.0	0.0	<0.1	0.0	0.0	<0.1	-	0.2	0.4	10.8	5.4
1986	0.0	0.1[b]	0.0	0.0	<0.1	0.0	0.2	<0.1	<0.1	0.4	<0.1	0.1	0.4
1987	0.0	0.0	<0.1	0.7	0.0	<0.1	0.0	0.0	<0.1[b]	<0.1	0.4	8.6	1.2
1988	<0.1	0.3	<0.1	0.0	0.0	0.0	0.0	<0.1	0.0	0.0	0.3	2.5	0.2
1989	<0.1	0.0	0.0	0.0	<0.1	0.0	0.0	<0.1	<0.1	0.1	0.7	1.1	1.2
1990	<0.1	0.0	0.0	0.0	<0.1	0.0	<0.1	<0.1	0.0	0.2	<0.1	0.5	0.8

[a] Tree was infected
[b] Included one European elm bark beetle

Trap locations:

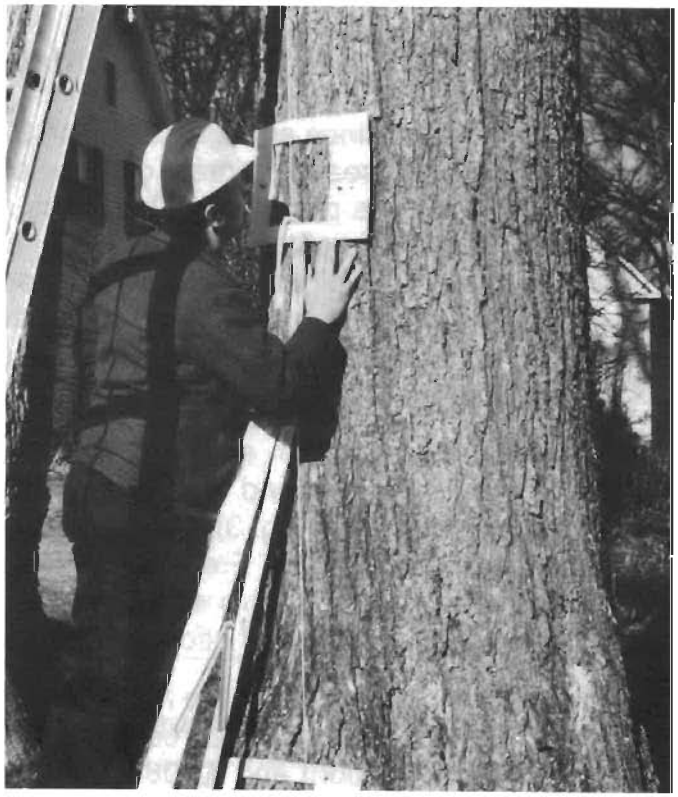
1. Cathedral
2. Old Burying Ground
3. Queen's Square
4. University Avenue
5. Government House
6. Wilmot Park
7. Devon
8. Wilsey Road
9. Woodstock Road
10. Nashwaaksis
11. New Maryland
12. Estey Bridge
13. Cross Creek

Sticky trap around circumference of elm tree

Boring-dust counts (overwintering population) — In 1977, the overwintering bark beetle population was assessed in conjunction with the Dursban registration process. 'Boring-dust piles' in the lower 30 cm of tree trunks were counted. These piles are created when beetles burrow into the bark and push out boring dust. The results of the survey (Table 9) showed a remarkable reduction in the overwintering bark beetle population within the treatment area. They also showed that the initial population was lower in the sanitation area than elsewhere and that the highest population was on the north side of the City. This information contributed to the decision to clear-cut in the Nashwaaksis area.

Table 9. The effect of different treatments on overwintering adult populations of the native elm bark beetle in Fredericton and vicinity — Fall 1977

Location and treatment	No. of plots in area	No. of trees examined	No. of beetles/m^2
Fredericton Sanitation Area			
Trunk spray 1976 & 1977	4	34	0
Trunk spray 1976 only	2	20	1
Trunk spray 1977	2	20	0
No spray	5	45	18
No sanitation			
South side	2	14	86
North side	3	30	623
Outside Fredericton	4	39	419



Boring-dust count of overwintering population

In 1979, overwintering adults were again counted. Trees treated with Dursban in 1979 on both sides of the river were examined, as were trees on the south side where treatment was carried out in previous years but not in 1979, and trees on the north side where treatment was never applied. The results are shown in Table 10.

Table 10.Overwintering adult population in different areas of Fredericton — Fall 1979

Treatment	No. of trees	No. of beetles/m2
Treatment in 1979 (North & South sides)	9	6.6
Previously treated (South side)	5	14.8
Never treated (North side	6	227.2

Beetles in whole-tree sprayed elms — The effect of whole-tree Dursban spray was monitored by comparing losses to a randomly preselected sample of unsprayed trees. Losses observed among the sprayed trees (Table 5) were deemed to be too high and this led to the re-examination of the overwintering habit of beetles on Fredericton's large trees. Could it be that, in Fredericton, not all bark beetles migrate to the base of the tree to seek the protection of thick bark as they do in other areas of the country on smaller trees with presumably thinner bark in the crown? An examination of trees during the 1978-1979 winter cutting program found that beetles indeed overwinter in large numbers high in the crown, in the stem, and in thicker branches. Overwintering beetles were common as high as 11 m from the ground and were found much higher than that. Consequently, Dursban has not been used since 1980, as either a whole-tree or a basal treatment.

The Fredericton Dutch Elm Disease Management Area

It has been obvious since amalgamation in 1973 that the City would not be able to maintain the Dutch elm disease program over the entire Greater Fredericton area at the same level of proficiency as previously. There was serious doubt about the future of the program on the north side of the river in Devon, surrounded on three sides by high disease incidence in newly amalgamated communities. Records showed that, by 1975, 12% of the elms were infected in Devon, while on the south side, the infection rate was 7%. Although most of the losses were along the river bank and along brooks and the railroads, the infection rate was also rising in residential areas.

The City set as a minimum standard the removal of infected elm trees over the entire Greater Fredericton area and then concentrated efforts in a designated Dutch elm disease management area (Fig. 3). This area is comprised largely of the original residential and business districts of 'old' Fredericton. The plan was to expand this area gradually, as time and finances allowed. This was accomplished by the early 1980s and now the entire City receives a similar level of effort.

There were 5,692 elm trees in the management area in 1961 and there were 2,980 elms at the end of 1990. Of the 2,712 trees lost, 1,704 fell victim to Dutch elm disease (29.9% of the original population) and 1,008 were removed for other reasons (17.7%). The progression of the disease — and the success of the control program — are summarized in

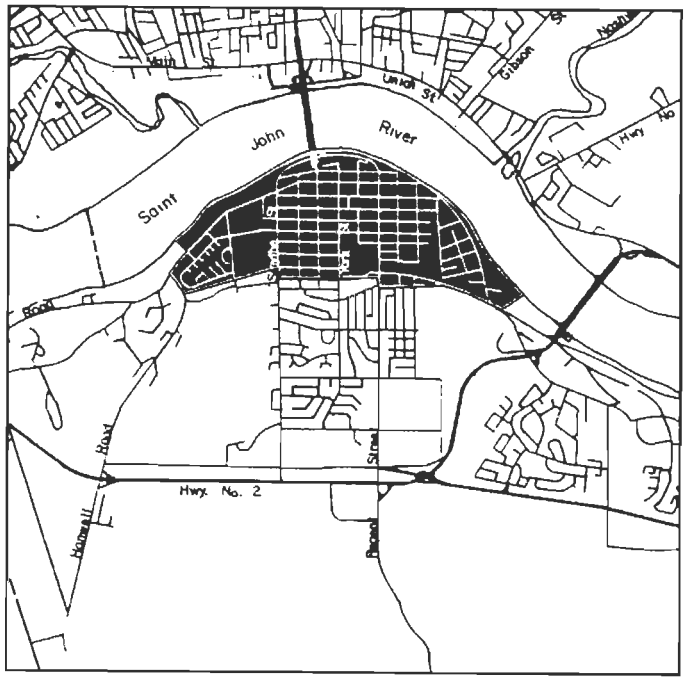


Figure 3. The Fredericton Dutch elm disease management area.

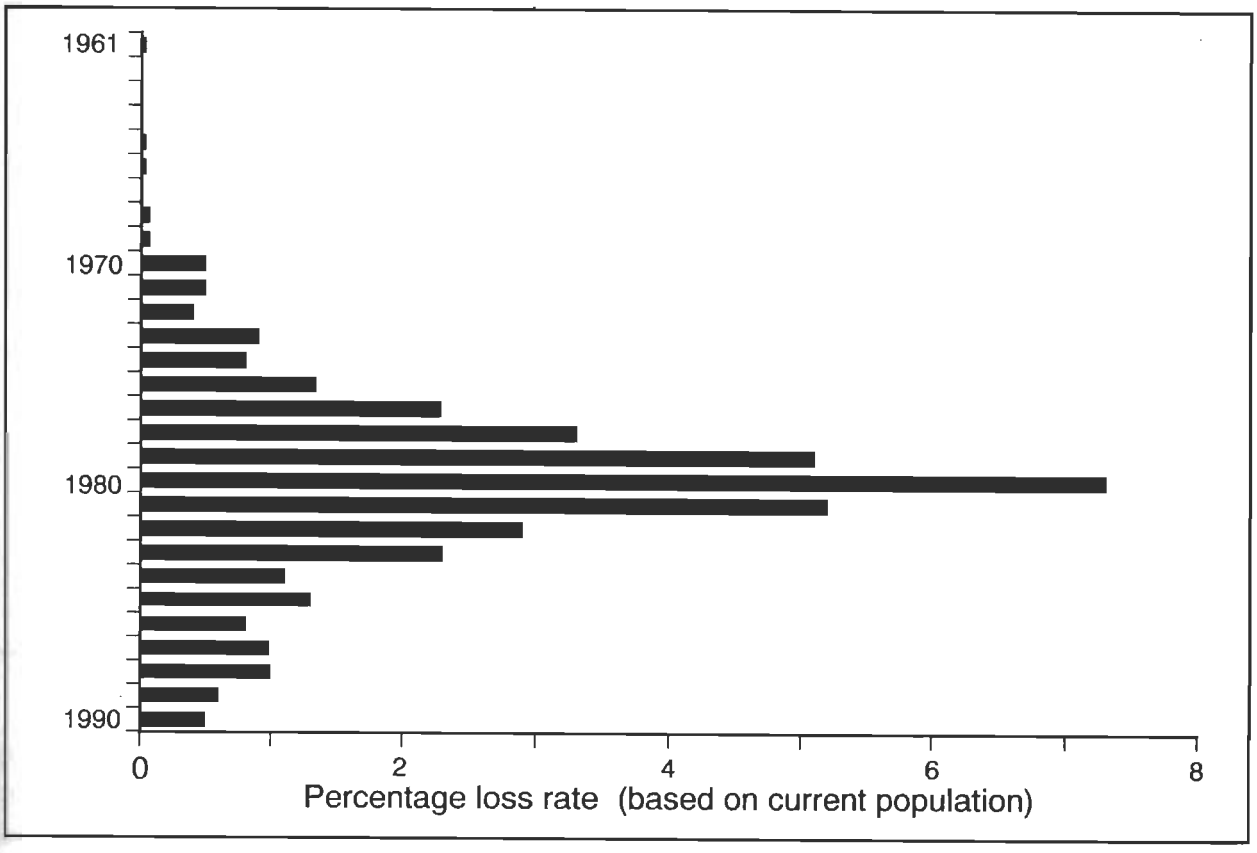


Figure 4. Dutch elm disease in Fredericton, 1961-1990

Table 11 and illustrated in Figure 4. The annual rate of loss to Dutch elm disease is expressed based on both the "starting tree population each year" and the customary "based on an estimated original population." The latter gives better-looking results, but does not reflect the actual situation.

Table 11. Elm tree losses to Dutch elm disease in the Fredericton Dutch elm disease management area*

Year	No. of trees removed		Disease to date	Accumulated loss to date to DED %	Annual rate of loss to DED based on:	
	Dutch elm disease	Other reason			Current population (%)	Original population (%)
1961	1	16	1	<0.1	<0.1	<0.1
1962	-	20	1	<0.1	-	-
1963	-	15	1	<0.1	-	-
1964	-	10	1	<0.1	-	-
1965	1	24	2	<0.1	<0.1	<0.1
1966	2	25	4	0.1	<0.1	<0.1
1967	-	50	4	0.1	-	-
1968	5	102	9	0.2	0.1	0.1
1969	6	39	15	0.3	0.1	0.1
1970	25	45	40	0.7	0.5	0.4
1971	28	37	68	1.2	0.5	0.5
1972	22	65	90	1.6	0.4	0.4
1973	47	41	137	2.4	0.9	0.8
1974	40	52	177	3.1	0.8	0.7
1975	63	74	240	4.2	1.3	1.1
1976	120	89	360	6.3	2.5	2.1
1977	79	144	439	7.7	1.7	1.4
1978	150	3	589	10.4	3.4	2.6
1979	219	21	808	14.2	5.2	3.8
1980	315	24	1123	19.7	7.8	5.5
1981	195	22	1318	23.2	5.3	3.4
1982	105	8	1423	25.0	3.0	1.8
1983	80	27	1503	26.4	2.4	1.4
1984	36	7	1539	27.0	1.1	0.6
1985	41	6	1580	27.8	1.3	0.7
1986	25	6	1605	28.2	0.8	0.4
1987	31	6	1636	28.7	1.0	0.5
1988	31	16	1667	29.3	1.0	0.5
1989	22	8	1689	29.7	0.7	0.4
1990	15	6	1704	29.9	0.5	0.3

(*Original elm population in 1961 — 5,692 trees)

The number of elms lost year by year, expressed in terms of trees present in the spring of that year, gives an annual loss rate higher than if expressed in terms of the starting tree population. Trees removed for any reason during the previous year were deducted from the inventory each year to arrive at the current population. This method gives a

more realistic estimate of losses for any given year, because it is based on what is actually there to become infected.

Fredericton's original elm inventory included only trees with a minimum 10-cm diameter. The inventory is updated at infrequent intervals. In intervening years, the most recent figure is used and it does not take in-growth into consideration. Losses, however, include all trees regardless of size. This system exaggerates calculated losses and, in the long term, underestimates the number of trees present in the City. In 1978, the date of the last inventory, it was found that although 1,600 elm trees were removed between 1957 and 1978 for various reasons, Fredericton's elm tree population decreased by only 575 trees (Magasi 1979). We believe that the same situation exists now. There have been 127 elms removed since 1978, classified as "trees of little value," most of them small and unlikely to have been part of the latest inventory. The same is also true for many of the trees on private property. Yet, these are used as trees lost in calculations. Because of these points, it is likely that loss figures given in the body of this report present a worst case scenario.

In 1961, regular City blocks of 1.8 ha (4.5 acres) maintained an average of 60 elm trees per residential block (32.9 elms/ha or 13.3 elms/acre) with a range from 8 to 101 elms. At the end of 1980, 20 years after the arrival of the disease, the average density was 41 elms per block (22.5 elms/ha or 9.1 elms/acre). Some blocks have suffered heavier losses than others. Most of the problem areas, where losses exceeded the average by more than 10%, were on the periphery of the management area, with the notable exception of the Old Burying Ground and vicinity.

As stated above, an examination of the tree removal patterns since 1978 (Table 12) reveals that 58.5% of the elms cut in the management area are backyard trees or elms of little value, *e.g.*, small groups of young trees along property lines, along railroad rights-of-way, thickets, *etc.*; however, all these are included in loss calculations.

Table 12.The proportion of diseased elm trees removed — by ownership and value — in the Fredericton Dutch elm disease management area

Year	Total	Large trees				Trees of little value	
		City trees		Private trees			
		Number (Class 1)	Percent	Number (Class 2)	Percent	Number (Class 3)	Percent
1978	150	65	43.3	75	50.0	10	6.7
1979	219	97	44.3	66	30.1	56	25.6
19 80	315	118	37.5	161	51.1	36	11.4
1981	195	83	42.6	112	57.4	-	0.0
1982	105	51	48.6	54	51.4	-	0.0
1983	80	36	45.0	44	55.0	-	0.0
1984	36	11	30.6	25	69.4	-	0.0
1985	41	18	43.9	19	46.3	4	9.8
1986	25	10	40.0	15	60.0	-	0.0
1987	31	8	25.8	21	67.7	2	6.5
1988	31	14	45.2	17	54.8	-	0.0
1989	22	10	45.5	2	9.0	10	45.5
1990	15	4	26.7	2	13.3	9	60.0

At the end of 1990, about 1,000 of the 2,980 elms in the management area are large trees on City property or in front of houses on private land and comprise part of the 'street scape.' High-value trees of special importance (along with trees of other species) are selected from these in the process of stratifying the inventory of the urban forest in Fredericton.

The Cost of Fredericton's Tree Program

From its inception until 1973, the program was solely supported by the citizens of Fredericton, through taxes. In the outside areas, the New Brunswick Department of Natural Resources and Energy bore the cost of removing infected trees in the early years of Dutch elm disease in the province (Smith and Forbes 1968). From 1973 to 1980, the province, through amalgamation grants, assisted in upgrading the tree-care standards in the amalgamated areas.

The operational costs, since amalgamation, of Greater Fredericton's tree program, which goes much beyond the mere management of the Dutch elm disease situation, are summarized in Table 13. Included are costs associated with all aspects of the work of the Parks and Trees Division, such as:

- tree and stump removal and disposal of all tree species, including hazard tree removal;
- buying new trees;
- planting programs, both replacement and planting in new developments;
- pruning programs and general tree maintenance of all tree species;
- experimentation with new techniques;
- technology transfer to other communities;
- chemicals and spray programs for Dutch elm disease control and the protection of all trees against other insects and diseases;
- pest control (including Dutch elm disease) on private property when necessary for the benefit of the City's program;
- public awareness and public education programs;
- new equipment; *etc.*

Table 13.The cost of the Greater Fredericton tree program since amalgamation in 1973*

Year	Total expenditures	City	Province	Canada Work Program
	(dollars*)			
1973	85,972	55,939	30,033	-
1974	100,111	50,111	50,000	-
1975	88,704	48,704	40,000	-
1976	89,401	49,401	40,000	-
1977	135,428	88,629	40,000	6,799
1978	214,950	103,488	61,184	50,278
1979	220,798	151,982	68,816	-
1980	212,057	147,057	65,000	-
1981	278,831**	278,831	-	-
1982	258,119	258,119	-	-
1983	314,415	314,415	-	-
1984	267,160	267,160	-	-
1985	272,748	272,748	-	-
1986	286,210	286,210	-	-
1987	290,227	290,227	-	-
1988	304,685	304,685	-	-
1989	333,132	333,132	-	-
1990	341,911	341,911	-	-

*All figures are actual for the year, no adjustments made for inflation
** There was a change in accounting procedures in 1981. Also, a new City Engineer was appointed

The actual cost directly related to Dutch elm disease, though at one time considerable and a major drain on the Parks and Trees Division's budget, is today but a continually decreasing fraction of total expenditures. Should Fredericton not have a single elm tree left, there would still be a tree program with most of the current cost incurred.

In spite of the introductory statement that the "purpose of the report was.... not to justify action," a brief explanation regarding the spending of some four million dollars seems in order.

What would have happened if Fredericton, like so many other communities, had decided to "throw in the towel" and give up on controlling the disease? A comparison with the situation at the intensification study plots (Van Sickle and Sterner 1976) is valid for reasons already mentioned and because the losses experienced on the plots were similar to those experienced in many North American communities. Figure 5 illustrates the difference between the retention of healthy elms in Fredericton and in nearby areas without a control program. By 1977, the City could have been left with practically no healthy elm trees, but would still have faced the enormous cost of removing some 5,500 large, dead trees, unsightly and hazardous to life and property.

Cost figures could be calculated for factors such as extra energy needed for cooling buildings because of the 16-19°C warmer temperature in the City without trees (Magasi and Harrison 1982), for changing the name of half a dozen businesses that proudly bear names associated with elms or of organizations and community events also connected

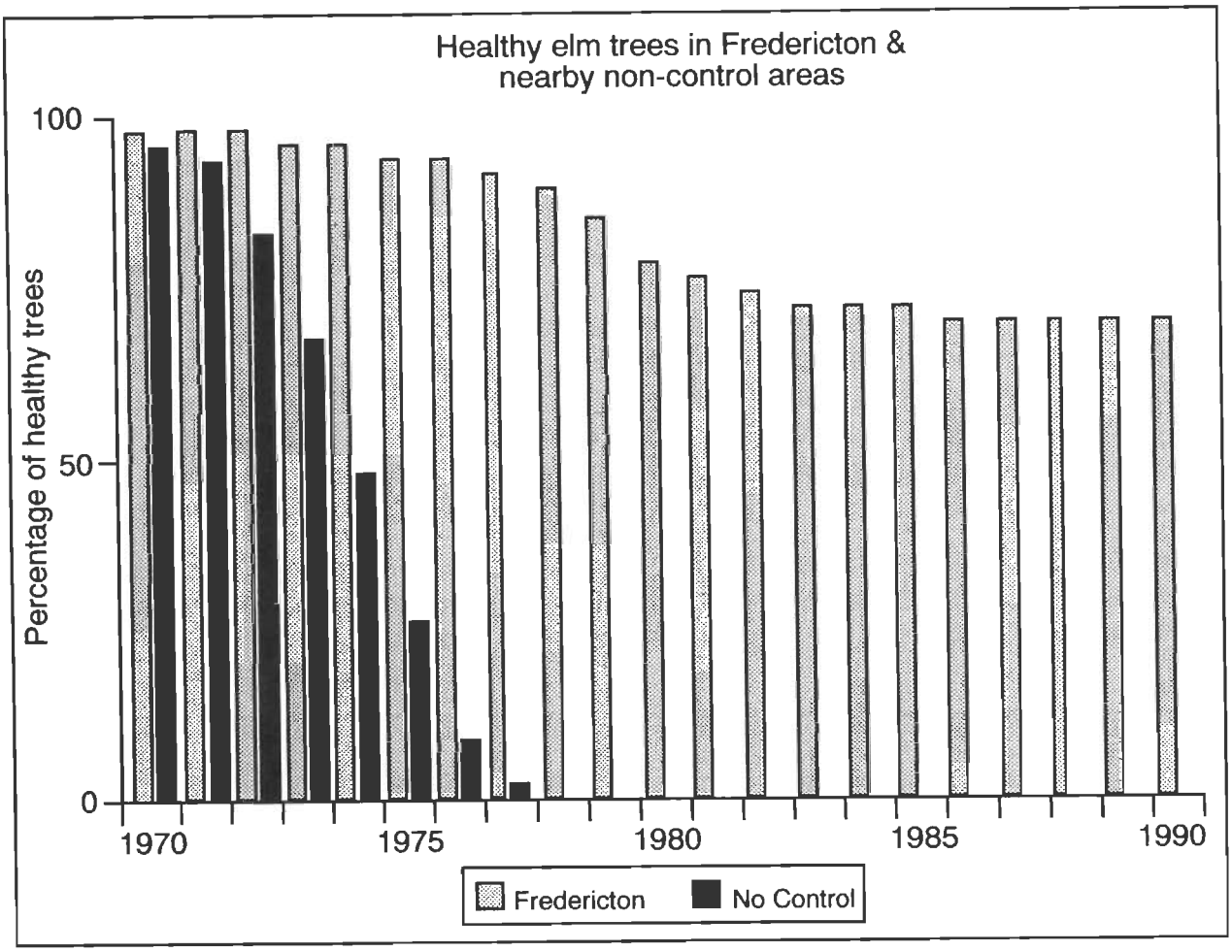


Figure 5.

to the species or for a drop in the tourist trade. No dollar value can be put, however, on quality of life, on heritage, on civic pride or on beauty.

With the management of Dutch elm disease and the rejuvenation program, Fredericton still has 3,000 beautiful, old elm trees to maintain the character of the City of Stately Elms and it has nearly 12,000 young, vigorous shade trees to ensure the future of the urban forest.

In addition to costs mentioned above, Natural Resources Canada, involved with the program from its beginning, has borne the costs of evaluation and monitoring, culture identification, assistance in tree marking, advice, and research associated with the project.

There is another factor to which no monetary value can be attached but without which the program simply would not have worked. That is, the continued commitment of City Council and the dedication of Tree Commission members who unselfishly donated their time and effort throughout the years.

Part IV
Fredericton's Dutch Elm Disease Story

There have been several distinct periods in the story of Dutch elm disease in Fredericton. There have also been several distinct but interconnected factors acting together in the right combination to account for the fact that the story's ending is a happy one. At the risk of further repetition, we feel that it is important to put Fredericton's efforts into perspective and summarize the past four decades in terms of "the rise and fall of DED."

Preparation 1952–1960

The Fredericton Tree Commission was formed in 1952, partly in response to concern regarding the spread of Dutch elm disease and partly in recognition of the fact that the City's thousands of century-old elm trees were facing an approaching threat. A by-law was enacted to authorize City staff to enter private property and cut diseased trees at the expense of the City. This by-law ensured the prompt removal of diseased trees in later years when the reluctance or financial inability of the owner might have caused delays. Sanitation pruning was carried out on all trees requiring attention. The disease was first found in the province in 1957 and, by 1961, was common and well established in central New Brunswick around Fredericton.

Invasion 1961–1969

The first infected tree was found in Fredericton in 1961 and was promptly removed. A total of 15 diseased trees were found during this period, 11 of them in the last 2 years. Although the disease was present in the City, the numbers were low and the annual loss rate was 0.1% (301 other elm trees were also cut during this period, to allow for construction and street widening, but mostly because of decadence, as part of a 'clean-up' after the establishment of the Parks and Trees Division).

Build-Up 1970–1975

The disease was running rampant in central New Brunswick and trees were dying by the thousands. Disease-carrying elm bark beetle populations were very high and the number of healthy trees was declining at an alarming rate.

In Fredericton, the number of diseased trees cut each year increased, the annual loss rate progressed slowly but steadily upward and surpassed the 1% mark for the first time in 1975. Still, compared to areas where the disease was allowed to run its course unimpeded, the effects of the City's control program became clearly evident. Fredericton was saving its trees. While an average of 72.0% of the trees were killed by Dutch elm disease in outside areas (Table 1), only 4.2% of Fredericton's trees succumbed to the disease by the end of 1975 — a 67.8% difference. The City lost 225 trees to Dutch elm disease between 1970 and 1975. Assuming the same rate of loss observed in areas without control that difference meant a saving of 3,767 trees in Fredericton that remained healthy and green, required no costly removal expense, and did not become the source of further infection. (The assumption is valid because, while there were no more than four

Only 4.2% of Fredericton's elm trees succumbed to Dutch elm disease by the end of 1975

infected trees in any of the four outside areas at the start of the study, there could have been, without a sanitation program, a minimum of 15 infected trees widely distributed in the City and the density of elm population was at least as great in Fredericton as in the outside areas.)

In 1973, amalgamation with several surrounding communities increased the size of Fredericton. In the ensuing years, considerable effort was expended to bring tree care to the standards of the 'old' city (Table 4, Fig. 2).

High Pressure and Peak 1976–1980

While Fredericton was clearly much better off than many other areas, it was becoming a green island in a sea of destruction. Most trees were dead in the outside areas (95% by the end of 1977) and there was an influx of disease-carrying beetles, in search of living elm, in the City, as evidenced by an increase in the beetle index (Table 8) and in the pattern of infected trees within the management area.

Sanitation was supplemented by the application of various chemicals during these years, aimed at lowering elm bark beetle populations.

The losses mounted during this period. The accumulated loss from Dutch elm disease more than quadrupled from 4.2% in 1975 to 19.7% by the end of 1980. The annual loss rate increased dramatically and, in 1980 alone, the City cut 315 diseased trees within the management area. Some 7.8% of the trees green in the spring were gone by the end of the year (Figure 4).

However, the City, despite growing losses, still had over 80% of its elm trees healthy in 1980 after 20 years of battling Dutch elm disease, a credit mainly to the sanitation program consistently carried out.

Downturn 1981–1985

In 1981, the annual loss rate dropped two and a half points to 5.3% — then consistently continued dropping each year. The loss rate was reduced to just slightly above 1.0% in both 1984 and 1985. There were occasions before — in 1972, 1974, and 1977 — when the annual loss rate was lower than the year previous, but those 'pauses' were temporary, probably a combined effect of biology and calculations, after which the upward cycle was restored. This time, the change in direction was real. With the drastic reduction of elms from the surrounding areas, elm bark beetle populations declined dramatically as indicated by the declining beetle index. The pressure was off.

Fredericton was still losing trees. In 1985, 41 diseased elm trees were removed from the management area. However, the losses were much smaller than they used to be. While the City lost 15.5% of its trees between 1975 and 1980, the loss was only slightly more than half of that between 1981 and 1985 (8.1%). Most of this was in the first part of the period.

It is true that 27.8% of the original elm tree population was lost to Dutch elm disease in the 25-year period following 1961, but this also meant that 72.2% of the trees were saved, a figure higher than that of the outside areas without control in 1973 — 13 years earlier.

Since 1981, historical and other high-value elm trees have been selected for extra attention and, to increase their chances of survival, some have been injected with chemicals to prevent infection. The number of trees injected has been few and has been restricted to high-value trees.

Under Control 1986–1990

In 1986, for the first time since 1974, infection rate was below 1.0% and remained there. No more than 31 trees were lost in any given year, one tenth of the record loss in 1980, and only about a third over 5 years of what was lost in a single year at the peak of the outbreak.

Over the 30 years, Fredericton saved over 70% of its elms from Dutch elm disease. Even after removals for other reasons are considered, the City still has almost 3,000 elms in the Dutch elm disease management area, a thousand of these high-value trees on City property or private land, comprising the 'street-scape' and adding to the ambiance of the City.

The fate of Fredericton's tree program has not been left to blind optimism alone. The pruning program on City trees continued unabated and more than 2,000 trees were pruned each year in spite of increased workload.

Although still proud of its elms and working hard to save them, the City long ago realized that it cannot rely forever for beauty and shade on the aging elm trees alone. Consequently, a vigorous tree-planting program with a variety of different species to provide diversity has always been high on the list of priorities. Over 700 new trees have been planted each year, some to replace trees lost (24%), but most to establish trees in newly developed areas.

A vigorous tree-planting program has been established in Fredericton

The Future 1991–

The infection rate for both 1991 and 1992 was well under 1.0%. With over 70% of the original elm population still healthy after 30 years of Dutch elm disease and with loss rates down, the future looks bright. The planting program will ensure a mixed urban forest with a diversified species composition. The sanitation program should ensure the continued presence of the magnificent old elms for a long time to come.

The catastrophe that befell surrounding areas has helped to relieve the pressure on Fredericton's trees. The virtual disappearance of elms fortunately did not mean the extinction of the species in the countryside. A few trees remained and seed from these took hold. A new generation of elm is growing. Unfortunately, the disease did not disappear altogether either. There are still some old surviving trees around, many of them diseased and there are signs of flare-up of the disease in some areas of the young trees. It is unlikely that Dutch elm disease will again sweep through the land as it did during the first wave, but it is also unlikely that it will disappear.

Therefore, while Fredericton may enjoy the beautiful old elm trees, it must be remembered that these are the remnants of a great stand which not that long ago covered the entire area. It must be remembered that they are still here because the City cared and worked hard to keep them. Fredericton must not become complacent. The greatest pressure is gone but the danger remains. Any relaxation of the persistent adherence to the sanitation program could, in short order, undo all the efforts of all those years.

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The authors feel privileged to have had the opportunity to prepare what they believe to be a historical document.

Appendix I

The Fredericton Tree Commission — 1952-1992

Founding Members

Jean Adams
Nelson Adams
R.E. Balch
J.E. Brawn
J.M Gibson
H.D. Long
J.D. MacKay

Mayors

H.S. Wright	1949-1956
W.T. Walker	1957-1969
J.W. Bird	1969-1974
E. Wilkins	1974-1986
B. Woodside	1986-present

City Councillors

(Reps. on T.C.)

L. J. Brewer	1958-1960
J.E. Brawn	1952-1954
W.G. Brown	1989-1992
A.M. DiGiacinto	1974
E.F. Gillies	1960-?
H. Hughson	1954-1955
R.L. Kilburn	?
Vera MacKenzie	1973-1974
Bruce Noble	1986-1989
R. Ogilvie	?
Mike Smith	1992-present
C. Weyman	1955-1957
W. Whittingham	?
R.L. Yeomans	1974-1986

City Engineers

J.D. MacKay	?-1953
W.L. Barrett	1953-1979
E.J. Bliss	1979-present

Honorary Member

Dr. J.J.F. Winslow, whose ancestors were responsible for planting many of the City's first trees.

Chairmen

K.B. Brown	1952-1954
H. Hughson	1954-1955
C. Weyman	1955-1957
C.C. Smith	1957-1978
J.H. Torunski	1978-1982
A. Dickson	1982-present

Members

Jean Adams	1952-1958
Nelson Adams	1952-1957
C.W. Argue	1957-1960
David Baird	1977-1978
R.E. Balch	1952-1984
H.W. Blenis	1973-1977
W. Brittain	1985-1991
K.B. Brown	1953-1957
J. Clark	1967-1971
A.G. Davidson	1957-1962
A. Dickson	1979-present
J.M. Gibson	1952-?
H.L. Goldham	1958-?
H.D. Long	1952-1957
H.G. MacGillivray	1975-1984
M.E. MacGillivray	1960-present
L.P. Magasi	1973-present
R.D. Magill	1985-present
M.B. Moore	1952-?
D.R. Redmond	1956-1957
R.A. Redmond	1973-present
G.A. Richards	1958-?
L.R. Seheult	1957-1974
C.C. Smith	1952-present
J.H. Torunski	1975-present
J.C. Veness	1952-1954

Note: This list is complete only as far as sketchy early records and fading memory allow. We sincerely apologize to anyone we may have inadvertently omitted.