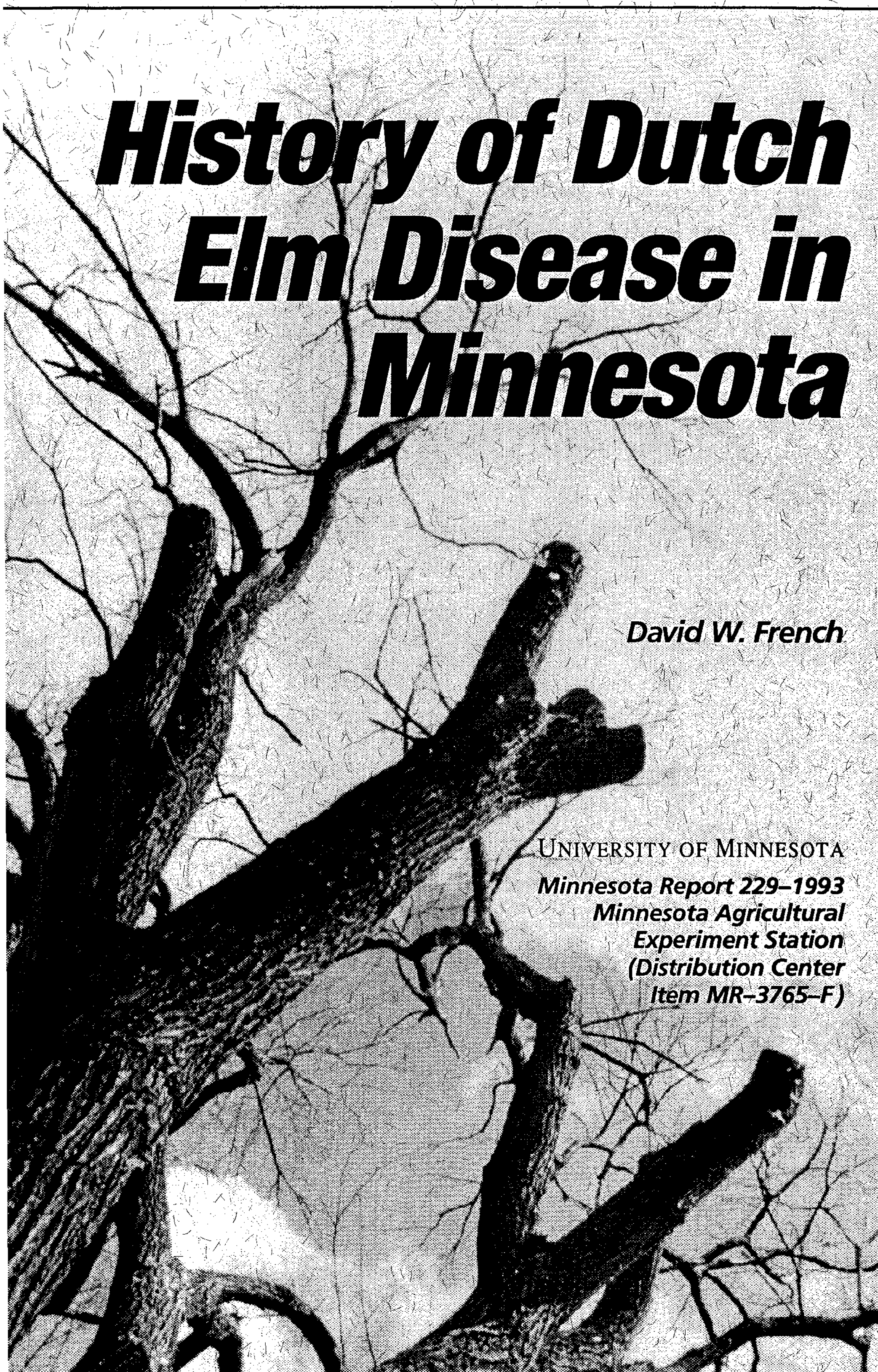
# History of Dutch Elm Disease in Minnesota



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# *History of Dutch Elm Disease in Minnesota*

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*Minnesota Agricultural Experiment Station*
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# Contents

# A Problem Denied: Dutch Elm Disease

***How could anyone be convinced to spend money on any program designed to reduce losses to Dutch elm disease when the disease wasn't even here?***

Minnesota was considered by many to be too far north for Dutch elm disease to be a problem. It was thought that the smaller European elm bark beetle, which had been the primary vector throughout the eastern states, would have difficulty surviving the harsh winters of Minnesota. It was almost impossible to convince people of the potential hazards of the disease when it was still well removed from the state's borders.

How could anyone be convinced to spend money on any program designed to reduce losses to Dutch elm disease when the disease wasn't even here? It wasn't even possible to convince people to stop planting elms, and nurseries were still promoting the elm as an easily transplanted fast growing tree that was resistant to pests and tolerant of harsh urban environments. It was also promoted as a tree that grows tall, beautiful, and lasts for more than a century.

In fact, nurseries continued producing and selling elms even after the disease entered Minnesota.

## *FIRST ARRIVALS*

We will never know exactly when Dutch elm disease first occurred in the state, but we do know it was found in the state for the first time in the early summer of 1961. This finding was identified from some branches from the Highland area of St. Paul, brought in by a tree service company. As far as was known at that time, only one tree was affected and it had wilted in 1960.

More diseased trees were found in 1961 in the Monticello area near the Mississippi River. That several trees were infected at that location suggested that the fungus had been there for at least a year, possibly longer. It is reasonable to assume that the fungus could have been present in one or more of Minnesota's southern tier counties, which were relatively near infested Iowa counties.

Dutch elm disease was also brought into Litchfield, probably in 1961. Many think that it likely arrived there in an automobile of a person returning from a visit to relatives in Illinois, a fact that was learned about accidently in 1987. While the evidence was circumstantial, it was learned that elm wood was brought to Litchfield from Illinois in that year, and a Litchfield elm died of Dutch elm disease shortly after.

The introductions of Dutch elm disease into St. Paul and Monticello were almost certainly the result of people moving the Dutch elm disease fungus, *Ceratocystis ulmi,* from some relatively distant location, either on beetles or in wood contaminated with the fungus. This belief comes from knowing that the nearest existing confirmed location of Dutch elm disease to St. Paul in 1961 was 100 miles into Wisconsin. The Monticello location was 140 miles distant from the nearest known source.

## *EARLY OPPORTUNITIES IGNORED*

It took 30 years or longer for the fungus to move to Minnesota from Ohio and other eastern states. Thus this state had ample time to take appropriate steps to reduce or delay the ultimate losses. But people failed to believe that the beetles could survive in Minnesota.

Our citizens and leaders should have acknowledged Minnesota's obvious reliance on elms in our urban forests and prepared for the possibility of infection. Minnesota had relied almost entirely on the American elm for its parks, its streets, and wherever people wanted shade trees.

As early as 1912, in its 30th annual report the Minneapolis Board of Park Commissioners called for planting 2,104 trees, all elms. By the time Dutch elm disease struck in this state, Minnesota had close to 140 million elm trees, and little else, lining its streets and streams. The predominance of elms, as the shade tree of choice, stretched from Iowa to Canada and Wisconsin to the Dakotas.

What could have been done in the 1950s or earlier to minimize the possibility of future elm tree losses in Minnesota? Most obviously, we first could have stopped planting elms. Elms in nurseries should have been destroyed and no new elms planted.

*Elms dominated yards, streets and parks as the shade tree of choice across the upper midwest, from Iowa to Canada and Wisconsin to the Dakotas. Minnesota had about 140 million elm trees in 1950.*

A second necessary precaution would have been halting the movement of elm logs, elm firewood, or any form of elm with bark. It should all have been halted, possibly by regulation, but preferably by the potentially far more effective creation of public support through publicity and public education.

Third, sick and dying elms should have been eliminated from cities and parks as much as possible.

Fourth, elms should have been discriminated against in wild and forested areas. Every logging operation should have prescribed removal of elm. Whenever possible, these trees should have been utilized or burned.

A few ineffective attempts were made to establish procedures which would have reduced the elm population, especially those elms thought to be most vulnerable to attack by bark beetles. These attempts were made by a Dutch elm disease committee formed in the 1950s, with representatives from the Minnesota Departments of Agriculture and Natural Resources, and from the University of Minnesota.

The committee considered the steps which should be taken and encouraged appropriate actions. Unfortunately, nurseries were reluctant to cooperate. They continued selling elms, and new suburbs, parks and streets were planted with elms. No formal government restrictions were enacted. Nor was there any publicity urging voluntary restriction of shipment of elm with bark into Minnesota.

All attempts to convince the legislature of the importance of initiating control programs, such as sanitation, were to no avail. Some individual legislators were interested and concerned, but other priorities took preference over concern about a tree disease which was not here and which many thought would be of little consequence.

After a few meetings the Dutch elm disease committee effectively ceased to function, but efforts by its members continued periodically, trying to convince the State Legislature that measures were needed to prepare for the possibility of the arrival of Dutch elm disease.

## *LATER OPPORTUNITIES MISSED*

Even after the disease was found in Minnesota there were excellent opportunities to take steps to reduce or slow subsequent disease losses. The state had almost a decade in which the disease remained at low levels and could have been managed. In the city of St. Paul, from 1961 through 1968 only 30 positive cases were officially reported. The disease was not found in Minneapolis until 1963.

Unfortunately, any enthusiasm for control programs was severely lacking. In fact, it seemed that the slow rate of increase simply confirmed the beliefs held by many that the European elm bark beetle would not survive well in Minnesota, and that the disease would never gain momentum.

As late as 1961, a letter from a University of Minnesota entomologist to the members of the Dutch elm disease committee urged that the initiation of sanitation procedures was not yet too late, but that time was running out: "If sanitation measures are not started immediately and effectively the devastation may shock the residents of this area. When this happens it will be too late to do something about the problem." [1]

During the decade of the 1960s a maximum effort would have prevented the disastrous losses of elm trees experienced by Minnesota in the 1970s. There were, in fact, unfortunate delaying activities that interfered with proper sanitation. One was the notion that an elm need not be condemned or eradicated unless confirmed by laboratory diagnosis to be positive for Dutch elm disease. The laboratory exercise was essentially of little value and dependence on it slowed control programs and provided citizens with a basis for arguing that their tree not be removed.

It really made no difference whether an elm tree died from Dutch elm disease or from any other cause — every dead or dying elm should have been eradicated. Bark beetles carrying the Dutch elm disease fungus invaded dead and dying trees irrespective of the cause of a tree's demise and each new generation of beetles emerged to carry the Dutch elm disease fungus to healthy trees. All species of elms in which bark beetles can live, not just American elms, needed to be included in a sanitation program.

*Beetles which carry the Dutch elm disease-causing fungus are only about one-eighth of an inch long. The holes they leave behind as they burrow into dead elm wood are barely the size of a pen point.*

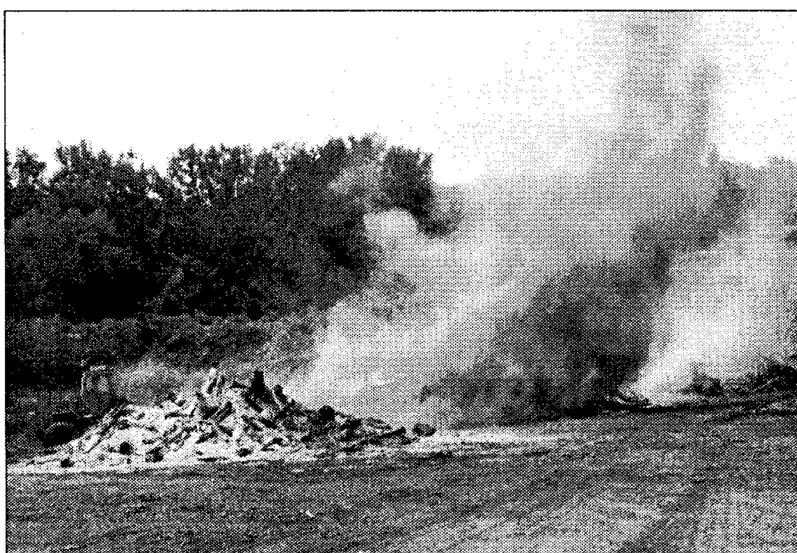
Even Siberian elms, which are not often killed by the Dutch elm disease fungus, will harbor bark beetle populations and fungus inoculum. Because Siberian elms are very susceptible to winter injury they often sustain considerable amounts of dieback which, while not disastrously harming the tree, is in-

[1] David W. French, July 24, 1961, personal correspondence to members of Minnesota's Dutch elm disease committee.

vaded by bark beetles carrying the Dutch elm disease fungus. The next generation of beetles, their progeny, emerge from these resistant elms carrying large numbers of spores of the disease fungus.

Burning has been the most expeditious method of eradicating elm material in which beetles could develop. Unfortunately, a then growing concern about our environment caused otherwise reasonable restrictions to be enacted against burning. Exceptions should have been granted to allow the burning of elm wood which could not be otherwise utilized. Reasonable numbers of fires and amounts of smoke should have been considered an acceptable environmental price to pay for being able to quickly eliminate large volumes of contaminated elm material.

History has proven that all other systems for disposal of large quantities of elm wood have been both more expensive and far less efficient than burning. If managed properly, in consideration of the energy situation, the people of the state of Minnesota could even have saved considerable amounts of money by burning elm locally, rather than insisting on its being hauled to distant disposal sites.



*Carefully managed burning should have been the disposal method of choice for beetle and fungus infected elm wood, but air pollution considerations severely restricted its use.*

## *FINALLY LEGISLATION*

It was not until 1971 that the State Legislature became concerned about Dutch elm disease. Even then, that concern was initiated and sustained by a small core of effective individual legislators. In particular, state representative Tom Berg initiated legislative involvement by forming a committee and holding extensive hearings on the subject prior to the convening of the legislature that year.

With its head start on the legislative session, the committee assembled a proposal and prepared a bill for legislative action. It moved slowly through the process, but it was ultimately passed. More than once it appeared that the bill would be tabled or voted down, but its supporters kept alive the legislation which eventually funded and set in place the largest program ever enacted by a single state to deal with a single tree disease. The bill did technically provide for programs dealing with oak wilt as well as Dutch elm disease, only a minimal effort was expended on the oak wilt problem.

At the same time that the State Legislature recognized the seriousness of Dutch elm disease and took action, congressmen from this part of the country responded at the federal level. In October of 1975, then United States Senator Walter Mondale, of Minnesota, introduced legislation to help at the congressional level. William Steigler, of Wisconsin, introduced the same legislation in the United States House of Representatives.

# Slowly, Steadily, Tree Infections Increase

***The stage was set for maximum losses of elms in 1977 because of wholly inadequate sanitation in preceding years***

Dutch elm disease developed more slowly in Minnesota than in states to the east and south. Exactly why its spread was slower is not known. A logical speculation is that European bark beetle populations did not survive as well here as in states with milder winters.

Based on laboratory confirmed cases of Dutch elm disease, the numbers of diseased elms was, for instance, lower each year in Minnesota than were the cases in Michigan and Wisconsin for the comparable early years of their encounters with the disease. (Table 1)

*Table 1. Laboratory confirmed cases of Dutch elm disease in Michigan, Minnesota and Wisconsin for comparable years following introductions of Dutch elm disease into each state.*

| Minnesota | | Wisconsin | | Michigan | |
|---|---|---|---|---|---|
| 1961 | 9 | 1956 | 63 | 1950 | 9 |
| 1962 | 2 | 1957 | 376 | 1951 | 74 |
| 1963 | 43 | 1958 | 1,832 | 1952 | 298 |
| 1964 | 54 | 1959 | 3,580 | 1953 | 1,119 |
| 1965 | 23 | 1960 | 5,342 | 1954 | 5,774 |
| 1966 | 49 | 1961 | 8,124 | 1956 | 7,614 |
| 1967 | 136 | 1962 | 7,196 | | |

Though the specific numbers comparing rate of increase of Dutch elm disease for different states can be questioned, the general trend does suggest that environment or some other factor held Dutch elm disease in check during its early existence in Minnesota. The diseased tree numbers do not, however, account at all for what happened outside of metropolitan areas.

One can never be certain that 1961 was the year when the Dutch elm disease fungus was introduced into Minnesota. While the first Minnesota diseased tree was reported in 1961, that tree was dying in 1960. The fungus could have been introduced in other locations, especially southern Minnesota, and not have been recognized. The first infected tree in Wisconsin, in Milwaukee, had been dying for three years before it was known to be a case of Dutch elm disease.

If we consider only the seven county metropolitan area of the Twin Cities where probably the best data are available, the losses for 1971 were only 421 trees. In 1972 and 1973 the losses increased to 977 and 1,457 respectively.

It was not until 1974, when losses jumped to 9,792, that the rate of increase changed substantially. The losses increased greatly in the following years: to 27,044 in 1975; to 75,460 in 1976; to 192,211 in 1977.

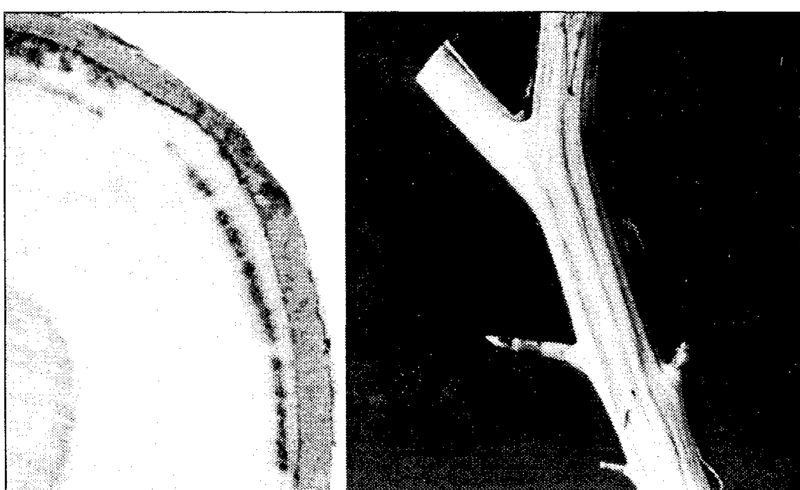
*European elm bark beetles burrow into dead elm wood. The primary carrier of the disease-causing fungus in the southern part of Minnesota, it is actually a very small, inconspicuous insect about one-eighth inch long. The better adapted native elm bark beetle spread the fungus in northern Minnesota.*

Data shows that 1977 was the year of greatest recorded losses to Dutch elm disease. The factors accounting for maximum losses in 1977 can be explained in part on 1976 weather favoring the beetles, and because effective control programs were not underway until 1977. This is when major funds were made available by the state legislature.

## *RURAL COUNTIES ALSO HIT*

While it was not possible to determine accurate numbers of diseased elms in rural areas, an effort was made to detect the first case in each county. This provided Minnesota with an approximate record of how the disease spread throughout the state.

By the winter of 1982-83, Dutch elm disease had not been found in only three of Minnesota's 87 counties. All three of these were in the northern tier (Cook in the extreme northeast and Kittson and Marshall in the northwest). Dutch elm disease was reported from the southern tier of counties between 1967 and 1969, supporting suggestions that the fungus first entered Minnesota, as reported, in St. Paul and Monticello.



*A cross section and a branch stripped of its bark each show a characteristic discoloration that can indicate the presence of Dutch elm disease.*

There can be little doubt that the fungus was brought into Minnesota by some person or persons. This was not an exceptional event as the disease has typically been spread along highways and has hitch-hiked on vehicles. The first known incidence in Manitoba, for instance, appeared in Selkirk following a mobile trailer convention in their local park area.

At first the losses were very high in southern Minnesota and less in the northern portions of the state. This is probably due to the fact that the European elm bark beetle, which has been known to be present since 1961, is commonly found throughout the southern third of the state, including the seven county metropolitan area of Minneapolis and St. Paul. In northern Minnesota the native elm bark beetle is the primary vector. As the elms were lost in southern Minnesota the incidence of the disease subsided. By contrast, northern Minnesota has faced increasing losses of elms.

The stage was set for maximum losses of elms in 1977 because of wholly inadequate sanitation in preceding years. If the legislative support program had been initiated earlier this may not have happened.

Elm losses in 1977 were to a large degree due to substantial numbers of dead and dying elms in communities where beetles increased their populations. If the figures were available we would have known that the bark beetle populations were at very high levels in 1976. In addition to poor sanitation programs, the weather was favorable for the bark beetles. Adding to the problem, drought conditions in late summer predisposed the elms to beetle attack, especially in September and October of 1976.

## *PITCHOUTS AND INFECTION*

A total of 12 city parks and adjacent areas were surveyed in the fall and winter months of 1976-77 to determine how many elms had been attacked by elm bark beetles and approximately what percentage of those trees attacked became infected with Dutch elm disease. The results of this evaluation are summarized in Table 2 on the next page.

Of 872 healthy appearing elms observed at random, 126 of them, or 14.4 percent, had been attacked by bark beetles. Of these beetle attacked trees, 81, or 64.3 percent, died of Dutch elm disease in 1977. It's very likely the fungus actually killed more of the 126 trees, however, these trees were not checked

*Table 2. Number and percentage of elms with pitchouts (indicating beetle attack) and number and percentage of these elms that became infected as a result.*

| Location | Elms Per Acre | Elms With Pitchouts | | Pitchout Trees With Dutch Elm Disease | |
|---|---|---|---|---|---|
| | | Number | % | Number | % |
| Loring Park | 214 | 30 | 14 | 30 | 100 |
| Stevens Square | 112 | 42 | 37.5 | 40 | 95 |
| Pearl Lake Park | 77 | 0 | 0 | 0 | 0 |
| Minnehaha Park | 100 | 2 | 2 | 2 | 100 |
| Kenny Park | 16 | 1 | 6.3 | 1 | 100 |
| Como Park | 100 | 1 | 1 | 1 | 100 |
| Phalen Park | 104 | 8 | 7.7 | 7 | 88 |
| Douglas Triangle | 18 | 3 | 16.7 | 3 | 100 |
| Cedar Ave. (Plot 1) | 53 | 39 | 73.6 | - | - |
| Cedar Ave. (Plot 2) | 38 | 0 | 0 | - | - |
| Kenwood Park | 30 | 0 | 0 | - | - |
| Lake of the Isles | 10 | 0 | 0 | - | - |
| TOTALS | 872 | 126 | 14.4 | 81 | 64.3 |

in 1978 or subsequent years to see if additional elms had died.

The drought conditions that were present at this time not only predisposed elms to attack by bark beetles but also resulted in mortality in trees of many other species. Tens of thousands of paper birch trees succumbed, as did many Norway spruce and other conifers. Rainfall in August and September 1976 was only 2.81 inches, considerably below the normal rainfall of 5.78 inches for this period.

## DOWNSIDE OF THE EPIDEMIC

In the years since 1977, elm losses have continued at a high level in wild or rural areas, but have subsided in cities and towns with substantial control programs. Minneapolis, the largest city in Minnesota, had one of the largest populations of elm, and came eventually to have one of the most vigorous control programs. The city was estimated to have between 200,000 and 600,000 elms before the advent of Dutch elm disease. The lower of these two figures is believed to be the more accurate.

As was true for the state as a whole, the disease in Minneapolis developed very slowly at first, with only 150 diseased or dead elms reported from 1964 through 1971. Losses increased rapidly each year through 1977. As the legislative support program had its impact on control efforts, the losses were sharply reduced thereafter. (Table 3)

*Table 3. The increase of Dutch elm diseased trees in Minneapolis through 1977; and the decrease following control program enacted in 1977.*

| Increase: | | Decrease: | |
|---|---|---|---|
| 1972 | 222 | 1978 | 20,813 |
| 1973 | 225 | 1979 | 6,751 |
| 1974 | 937 | 1980 | 4,184 |
| 1975 | 1,688 | 1981 | 5,068 |
| 1976 | 7,239 | 1982 | 3,389 |
| 1977 | 31,475 | 1983 | 2,144 |
| | | 1984 | 4,965 |
| | | 1985 | 4,087 |
| | | 1986 | 2,896 |
| | | 1987 | 2,280 |

The losses in 1978 remained fairly high, almost 21,000 elms, because of the carry over from 1977. Since that time the losses have stabilized at a relatively low level. What is important is that because of an aggressive sanitation program, the city still has close to 100,000 elms. The actual number may even be greater because of new elms which were nonexistent or too small to be counted in 1963. The American elm is a prolific seed producer and there will always be new elms establishing themselves.

The cost of reducing the elm tree losses was substantial. The total cost of the program in Minneapolis, including tree and stump removal, trimming, insect and disease control, inspection and replanting was $8 million in 1978 alone. (Table 4) In addition to the costs from 1977 through 1981, an additional $2 million from the State Legislature was spent on the program.

*Table 4. Cost to the City of Minneapolis for Dutch elm disease control, 1978 through 1987, including tree and stump removal, trimming, insect and disease control, inspection and replanting.*

| | |
|---|---|
| 1978 | $8.0 million |
| 1979 | $6.7 million |
| 1980 | $6.7 million |
| 1981 | $7.0 million |
| 1982 | $5.3 million |
| 1983 | $5.0 million |
| 1984 | $5.2 million |
| 1985 | $5.1 million |
| 1986 | $5.0 million |
| 1987 | $5.6 million |

# Legislation Finally Arrives

***If the legislature had not finally acted when it did, the American elm would have been essentially eliminated from Minnesota***

When talking about Dutch elm disease in forest pathology classes, an instructor could note that not much support was forthcoming from the state legislature until a magnificent elm in front of the State Capitol succumbed to Dutch elm disease in 1973. It has, in fact, been occasionally suggested by individuals that the tree was deliberately inoculated with the fungus, but that is not likely to have been the case. Several other elms on the Capitol grounds also died that year. The story does, however, poetically suggest that perhaps something so dramatic could have been done in the early 1960s to shake the legislature into acting sooner to enable control of the disease.

One of the early attempts to engage the legislature occurred in 1955. In that year an effort was made to convince a legislative committee that Dutch elm disease was going to threaten Minnesota's elms and that the best time to deal with the disease was before it arrived. The request of the committee was for an allocation of $5,000. It would have been a small price to pay for delaying the onset of Dutch elm disease.

The next attempt to influence the legislature took the form of a committee with membership drawn from state and federal agencies and the University of Minnesota. The university's representatives included Minnesota Agricultural Experiment Station personnel as well as extension representatives from the Departments of Plant Pathology, Entomology, and Forestry. State of Minnesota representatives came from the Division of Plant Industry of the Minnesota Department of Agriculture, and the Division of Forestry of the Department of Conservation (now known as the Department of Natural Resources). The federal government was represented by individuals from the Lake States Forest Experiment Station of the U.S. Forest Service.

This committee was organized in 1958-59 but very little resulted from its efforts. One thrust of their activities was the attempt to encourage regulating agencies to restrict the movement into Minnesota of elm with bark; but no positive actions were taken by any of those agencies.

The committee's second, and probably more important objective, was to publicize the threat of Dutch elm disease and prepare educational materials. Though this was done, the efforts appeared to have had no appreciable effect on the progress of events. At about the same time that the committee was operating, the Department of Agriculture requested $10,000 from a legislative Interim Committee on Forestry. Though this legislative committee seemed to be supportive of the need, no funds were made available.

In 1973, under the guidance of the Metropolitan Inter-County Council and its executive director, James Shipman, a new ad hoc committee was assembled. Representation on this committee included people from Minnesota's Departments of Agriculture and Natural Resources, Ramsey and Hennepin Counties, and the University of Minnesota, plus the city foresters of Minneapolis, St. Paul and Bloomington.

This committee met many times during the year and prepared a report whose recommendations included the appointment of a Shade Tree Advisory Committee to advise both the Commissioner of Agriculture and the public on how best to control tree diseases such as Dutch elm disease and oak wilt. The committee was established and continues in existence today.

Eventually, after many disappointing experiences dealing with subcommittees and committees of both the Minnesota House of Representatives and the State Senate, and with the impact of Dutch elm disease becoming clear within Minnesota, the Legislature appropriated $1.5 million for the biennium of 1976-77. In the following biennium $28.6 million was appropriated.

The $28.6 million appropriation was undoubtedly the largest single sum of money ever spent by any state any time in history to control essentially a single tree disease (a very small portion of the appropriation was directed toward control efforts for oak wilt).

Several people and organizations played particularly important roles in helping to achieve an effective state-wide control program. Key legislators included former State Senator Skip Humphrey and the most important person of all, former State Representative Tom Berg. Many individuals provided invaluable testimony to help sway the opinions of legislators. This testimony came from Dave French of the University of Minnesota, and from Peter Grills and others with the Department of Agriculture. Down the home stretch, as the final legislative appropriation votes approached, Don Willeke, a Minneapolis lawyer and chairperson of the Shade Tree Advisory Committee, was a key person. Outside organizations such as the First Minneapolis Bank also helped. First Minneapolis Bank, for instance, housed an answering service established to respond to the many inquires coming from the public.

It needs to also be appreciated that the $28.6 million was not even the whole of the money spent for Dutch elm disease control in Minnesota in that biennium. In fact, the money was primarily used as matching funds for communities participating in the control programs. Taking into account these matched dollars, the actual amount spent on Minnesota's Dutch elm disease

*The cost of removing mature elms was at least $100 per tree. This does not account for the landscape and property value losses that accompanied those removals. Large shade trees can add thousands of dollars to a property's value.*

control programs was closer to $60 million during the 1977-78 period. Even the portions of appropriated funds used for research and for utilization grants were matched by funds from other sources.

## *TOO LATE? YES AND NO!*

Many have asked if the Legislature acted too late to save the elms. The answer is both yes and no. Certainly, if funds had been available sooner the losses would have been much less. Clearly, St. Paul would not have lost over 50,000 trees in the one year of 1977, and the financial cost associated with that loss was not negligible.

If we very conservatively estimate cost of removal at $100 per tree, (well below the average for elm removal), the cost for removal alone is $5 million. And this does not account for the landscape and property value losses that accompanied the removal of those mature and majestic trees. Some large shade trees have been determined by courts to be worth as much as $10,000, but even if each elm lost is valued by the property owner at only $200, this means another $10 million loss in St. Paul alone.

If action had started no later than 1970, the rate of losses occurring in Minnesota communities could have been slowed dramatically. The accumulated losses sustained by 1980 might have been stretched into the 21st century. By then, in many cases elms would have been removed for other reasons — because they were overmature and hazardous — rather than because they were victims of the Dutch elm disease epidemic.

On the plus side, if the legislature had not finally acted when it did or had not provided the high level of funding, (an aggregate amount of almost $56 million over several biennium) the American elm would have been essentially eliminated from Minnesota. The only surviving mature elms would have been those in the few cities which maintained their own control programs. It is doubtful that more than a few would have made much effort to deal with Dutch elm disease without the backing provided by the state's resources.

This does not mean that the American elm would have disappeared completely, only that we would have lost over 90 percent of our elms of any appreciable size. Elms are prolific seed producers and are aggressive as seedlings and young trees (a fact that most people who have had to weed elm seedlings and saplings from gardens are well aware of). One actual count of 48 elm seedlings in a one foot diameter area around a newly planted street tree is a typical example.

The American elm or its close relative, the slippery or red elm, will definitely survive. Unfortunately, the large beautiful elms that were so important to our streets, parks, and yards are only here today because of the positive actions taken by our legislature in the allocation of funds for the creation of control programs.

From the viewpoint of a forest pathologist, one other positive accomplishment has resulted from Dutch elm disease. In Minnesota, there is now an increased knowledge of trees and tree problems. Before the days of Dutch elm disease there were very few people qualified to manage trees in cities and those so assigned had little appreciation and understanding of diseases. Today we have many people who are well informed and highly capable of dealing with tree problems.

## *A FEDERAL DEMONSTRATION PROGRAM*

On February 2, 1977, the Deputy Assistant Secretary of the U.S. Department of Agriculture wrote to Minnesota Congressman Donald Fraser (later mayor of Minneapolis) indicating that the Department of Agriculture had not made any Fiscal Year 1977 supplemental funding requests for research on Dutch elm disease. The proposed FY 1978 Dutch elm disease research budget request was proposed at $1,310,400. There were no control funds proposed for the FY 1978 budget. The assistant secretary's letter also estimated that there were 32,610,000 elms remaining in states where the disease had been reported. A reasonable assumption is that this must refer only to elms in cities, as there were about 140 million elms in Minnesota alone prior to Dutch elm disease reaching this state.

Early in 1977, Representative Fraser is known to have reported on Minnesota's Dutch elm disease control efforts to the House of Representatives. He was encouraging the federal government to recognize and do something about the problem. Also at about that time, the Office of the Secretary of the U.S. Department of Agriculture submitted a report to the President and the United States Congress on the problem of Dutch elm disease.

These and other pressures led Congress to grant the U.S. Forest Service $2.5 million in General Forestry Assistance funds for Dutch elm disease special projects. The objective set for these projects was to provide, on a nation wide basis, educational programs and information to communities, municipal governments, landowners, and individual homeowners. That information was to cover the history of Dutch elm disease, its incidence and severity, and ways to both control Dutch elm disease and utilize elm trees infected and killed by the disease.

A second objective of the new federal program was to establish and maintain demonstration projects in selected areas of the United States to show the application and results of effective Dutch elm disease control and elm tree utilization programs. The program, which was to last five years, began operation in early 1978, though programs were not actually established and functioning until the summer of that year.

It was helpful to have the increase in educational programs; the federal funds were responsible for upgrading the knowledge that people had of the disease. The utilization program, however, was of questionable value. Large sums of money were invested in promotions which appeared to have had little effect on the course of Dutch elm disease.

In the first year in Minnesota, $92,500 of federal funds were spent on a "densification" project at the Stillwater prison. This was to produce fuel from elm debris for producing energy at the prison. While there are no reports of whether or not this project succeeded, it certainly was of no value in actually controlling Dutch elm disease, and probably was of little value to the state prison.

These types of projects were unfortunately funded, by those in control of the funds, against the advice of an ad hoc steering committee. However, they learned from those mistakes and after the first year the money for utilization went to the demonstration communities for the purchase of debarkers and chippers which helped to eliminate bark beetle habitats.

Five states received federal funds and each organized its demonstration projects differently. Most of Minnesota's effort and federal program funds went into the management of Dutch elm disease in six cities selected to demonstrate that we did know how to reduce losses to Dutch elm disease. The cities selected represented different regions and different levels of incidence of Dutch elm disease. Two cities were selected from each of three regions. More repli-

*Utilization of removed elm wood was one objective of early federally funded projects. One project attempted to use the wood, ground up and shaped into fuel pellets, as an alternative fuel for some stoves and boilers.*

cation would have been desirable, but it was necessary to concentrate the funds to be certain that the programs for demonstrating reduction in Dutch elm disease would have adequate support.

Twelve other Minnesota cities, four from each region, were selected as controls to be compared with the six cities where supposedly the best designed programs were in place. No added effort was to be put into these reference cities over and above what they would have done anyway. As much as possible each reference city was comparable to one of the demonstration cities in size, location, and incidence of Dutch elm disease (Table 5, next two pages). This was not as well replicated an experiment as would have been desirable, however the amount of funds available limited what could be attempted.

The demonstration cities, with all their federal funds and considerable advisory assistance, did not fare much better than the reference cities which only had state funds. From the results of these projects it was possible to conclude that the activities enabled by the availability of state funds were by them-

*Table 5. Percent losses to Dutch elm disease in six federally funded demonstration cities (D) and in 12 comparable cities which were not recipients of federal funding.*

| City, County | Total Elms in 1977 | 1977 | 1978 | 1979 | 1980 | 1981 |
|---|---|---|---|---|---|---|
| | | % Losses in each year | | | | |
| (D) Fergus Falls, Ottertail County | 16,500 | .24 | 0.82 | 0.71 | 1.54 | 0.85 |
| Alexandria, Douglas County | 6,500 | | 1.40 | 1.35 | 1.58 | |
| Elbow Lake, Grant County | 1,525 | | 4.07 | 1.18 | 1.05 | |
| (D) Granite Falls, Yellow Medicine County | 10,775 | 1.11 | 3.14 | 2.48 | 2.99 | 2.37 |
| Ortonville, Big Stone County | 14,158 | | .78 | .35 | 1.05 | |
| Redwood Falls, Redwood County | 16,500 | | 2.94 | – | – | |
| (D) Hutchinson, McLeod County | 14,011 | .88 | 9.87 | 7.51 | 6.89 | 9.07 |
| Glencoe, McLeod County | 8,605 | | 1.93 | 1.24 | 1.65 | |
| Olivia, Renville County | 1,542 | | – | 5.12 | 5.38 | |

selves effective in reducing the elm losses. Another reasonable conclusion was that if a city had no program at all, their losses would have been much higher than in these 18 cities.

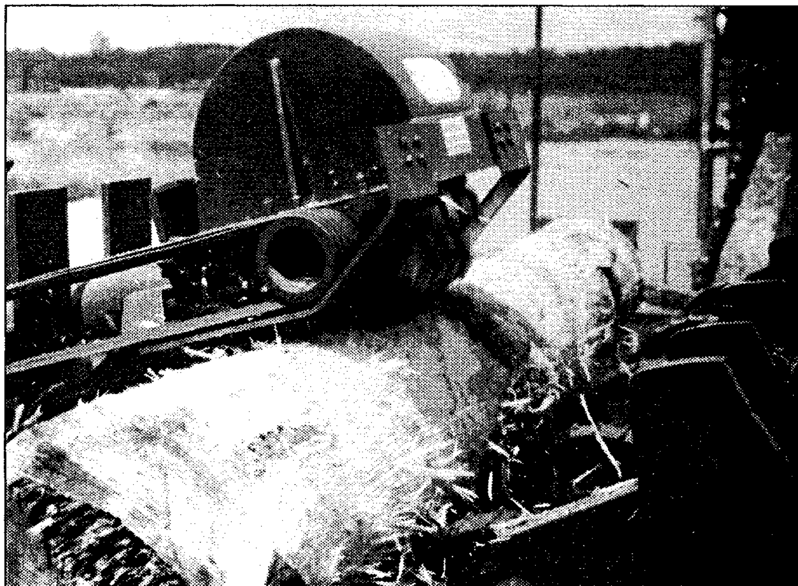
The demonstration just was not convincing. Hutchinson had substantial losses even with the additional federal assistance. The degree of success in Hutchinson might have been determined more by the Dutch elm disease situation prior to 1977 than by any other factor. If the beetle population was high in previous years, it would take a year or more to bring losses down appreciably. There might also have been additional factors influencing the different patterns of loss.

*Table 5 (continued). Percent losses to Dutch elm disease in six federally funded demonstration cities (D) and in 12 comparable cities which were not recipients of federal funding.*

| City, County | Total Elms in 1977 | % Losses in each year 1977 | 1978 | 1979 | 1980 | 1981 |
|---|---|---|---|---|---|---|
| (D) Litchfield, Meeker County | 8,300 | 1.17 | 3.79 | 3.42 | 3.51 | 5.11 |
| Hector, Renville County | 920 | | – | 5.98 | 5.98 | |
| Renville, Renville County | 1,802 | | 1.66 | 2.72 | 3.50 | |
| (D) Little Falls, Morrison County | 7,947 | 4.88 | 5.57 | 4.49 | 3.33 | 4.59 |
| Princeton, Mille Lacs County | 3,873 | | 5.27 | 3.00 | 2.12 | |
| Cambridge, Isanti County | 1,562 | | 9.92 | 5.25 | 4.48 | |
| (D) Wadena, Wadena County | 5,930 | 0.08 | 1.92 | 1.54 | 2.16 | 2.36 |
| Sauk Centre, Stearns County | 4,850 | | 1.92 | 0 | 1.75 | |
| Staples, Todd County | 1,050 | | .95 | 3.43 | 1.52 | |

The year 1977 was favorable for high losses of elm trees if a city had a substantial loss the previous year; a loss in the vicinity of 3 percent of their original population of elms. By contrast, because Fergus Falls had losses amounting to only .37 percent of their original population in 1977, it is not surprising that their losses were low in subsequent years. These losses were low largely because they are in the northern part of the state and the fungus had not reached there until 1970. Elbow Lake, though not in the federal program, reduced their losses from over 4 percent in 1978 to about 1 percent in subsequent years.

Little Falls, even with federal help, continued to lose elm trees between



*Tree debarking equipment was partly funded through federally supported utilization projects. Debarking, to destroy beetle colonies, was essential for any elm tree wood that was to be saved for manufacturing into products or stockpiled for later use as firewood.*

3.33 percent and 5.57 percent per year. Both Princeton and Cambridge, selected as references to Little Falls, showed improvement from 5.27 to 2.12 percent and 9.92 to 4.48 percent respectively during the same period of time.

Obviously factors other than the federal assistance program determined what happened. The story might have been different if the 12 reference cities had received no state support for their Dutch elm disease programs, but the fact that a city was not in the state program did not mean that they did not have a good program. Duluth did not participate in the grant-in-aid program and yet was able to maintain minimum losses. Of their population of 37,560 elms in 1977 they lost .46, 3.52, .46 and 1.20 percent of their elms through 1980. Obviously they managed well without state support.

The utilization portion of the federally-supported project had a 1979 plan which called for $126,837 for a portable debarker, a log splitter, two trucks, a front-end loader, two operators, and other miscellaneous items. Actual expenditures reached $139,628. The use of this equipment resulted in more efficient disposal of elm and put it into a useful form, firewood. Although there were frequent and lengthy discussions of how to better use the elm (for veneer logs, railroad ties, fencing, interior panelling, skateboards, etc.) and some research showed that elm could be used effectively for sound barriers and panelling, none of these alternative uses materialized.

# Success Stories, and Failures Too

***Emphasis should have been on saving the largest possible population of elms, many of which were 60 to 80 years old***

Tree losses in Minneapolis have been previously presented to show how effective the control programs were and how, even with a late start, it has been possible to save a large proportion of the elms (Table 3). The Minneapolis record would have been even better were it not for the drought conditions of 1976 which led to massive beetle attacks that fall, and if they had not had major problems organizing sanitation programs in 1977. It took a great deal of effort to find enough qualified contractors to remove the large number of trees that had to be dealt with in that year.

Minneapolis is not the only city to effectively deal with Dutch elm disease. A very similar story can be told for Robbinsdale, a northern suburb of Minneapolis. It is assumed that their total number of elms prior to Dutch elm disease was about 8,000. As was true for other communities, their losses were minimal until 1976. (Table 6)

In 1977, for the same reasons discussed previously, the incidence of Dutch elm disease in Robbinsdale jumped to 995. With state funds and improved management of the program, losses dropped to 514 in 1978. Since then losses have been fewer than 260 each year. Obviously the sanitation program was effective and the city has saved many of its elms.

In an unfortunate contrast, St. Paul bore the brunt of the disease attack. There were many factors that caused St. Paul to be further down the road of disease progress than other cities. This included the fact that the fungus was introduced to St. Paul early, around 1960 (and possibly earlier if the existence of some circumstantial evidence is to be believed).

*Table 6. Controlled annual elm tree losses in Robbinsdale, presented as an example of a Minnesota city that dealt effectively with Dutch elm disease.*

| Year | Number Lost | Year | Number Lost |
|---|---|---|---|
| 1972 | 7 | 1982 | 153 |
| 1973 | unknown | 1983 | 115 |
| 1974 | 42 | 1984 | 170 |
| 1975 | 64 | 1985 | 149 |
| 1976 | 493 | 1986 | 105 |
| 1977 | 995 | 1987 | 76 |
| 1978 | 514 | 1988 | 116 |
| 1979 | 188 | 1989 | 220 |
| 1980 | 108 | 1990 | 260 |
| 1981 | 223 | | |

The more rapid development of the disease in the southeastern section of St. Paul was in stark contrast to what happened elsewhere in the state. In this portion of St. Paul there were large concentrations of wild elms that were difficult to access because of the river and adjoining lowlands. Periodically for years the elms and other species suffered extensive flooding which provided many dead and dying elms where bark beetles developed large populations to spread into adjacent areas of St. Paul and the suburb of South St. Paul. One of the major disposal sites was also located in this same area, not far from Pigs Eye Lake which is part of the Mississippi River Bottom environment. Elm debris hauled to the dump was supposedly covered daily, but daily drives by this site clearly showed that the debris was not covered completely and that beetles had no problem escaping from the site.

The political climate in St. Paul also worked against control. The city had a treasurer who was reluctant to spend money on Dutch elm disease, and indeed received many letters from the public supporting his inclination to not waste money on trees. At that early stage many people failed to appreciate what was in store.

Researchers at the University of Minnesota warned St. Paul officials that to do nothing would still be costly, because hazardous dead trees had to be removed. The University had also emphasized that St. Paul's practice of using more salt on their streets in the winter than was customary for other cities

*Entire streets were quickly denuded of their mature shade tree elms because property owners and municipalities failed to recognize the presence or the seriousness of Dutch elm disease. Improved desease identification tecnhiques were one positive outcome of early control activities in St. Paul, Minnesota.*

was contributing to the numbers of dying and dead elms throughout the city. In traveling between metropolitan area cities drivers were aware of a safer feel of driving on St. Paul streets, however the salt was damaging elms, especially along main thoroughfares and at intersections.

A few years ago it was pointed out to then St. Paul mayor George Latimer, that he would go down in history as being mayor when all of St. Paul's elms would be gone. It was unfortunate for him because he was in no way to blame. The stage had been set and the disease well entrenched before he took office. In fact, under his guidance, St. Paul made a heroic last effort to save the situation. Despite budgeting $3.7 million to fight Dutch elm disease, St. Paul's cumulative losses had already climbed to 28,000 trees, with an even higher 35,000 future projection. In fact, the city's loss of elms passed 50,000 that year.

Prior to 1977 the city of St. Paul had 105,941 elms and had officially lost 46,754 or 44.13 percent of them. The losses dropped in subsequent years, largely because there were substantially fewer elms but also because of better sanitation. (Table 7)

*Table 7. St. Paul continued to lose elms after the disastrous year of 1977, though at a much lower rate because there were so many fewer elm trees left, and because sanitation efforts improved.*

| Year | Number Lost | Percent Lost |
|---|---|---|
| 1978 | 15,076 | 14.23 |
| 1979 | 6,069 | 5.73 |
| 1980 | 3,746 | 3.54 |
| 1981 | 5,561 | 5.15 |
| 1982 | 4,029 | 3.80 |
| 1983 | 4,627 | 4.37 |
| 1984 | 7,461 | 7.04 |
| 1985 | 4,331 | 4.09 |
| 1986 | 2,348 | 2.22 |
| 1987 | 2,679 | 2.53 |
| 1988 | 3,029 | 2.86 |
| Total | 58,956 | 55.56 |

In effect, St. Paul served the state as a testing ground for learning what to do to control Dutch elm disease, and from this standpoint aided all other Minnesota communities. For instance, spraying with methoxychlor in the spring was tried, only to learn that there were more problems than benefits. The city tried benomyl (the insoluble form), for which there had been claims of great success, only to learn that it was a waste of money.

St. Paul also learned early that detection was the achilles heel of their control program. When people who were selected for survey work could not even properly recognize elms, and marked ash and poplars as elms, detection efforts obviously suffered. But the failure demonstrated how important it was to hire people who knew something about trees and cared about what they were doing.

St. Paul supported early work in improved identification techniques, leading to an effective aerial detection system using 35 mm photography and a helicopter. St. Paul also learned early about the problem of spread through common root systems and tried, though unsuccessfully, to develop techniques to stop this means of spread.

Despite the magnitude of problems in St. Paul, the city did save a portion of their mature elms, and a planting program was begun to help the urban forest recover.

Many in Minnesota considered new planting to be a control measure for Dutch elm disease. This was very unfortunate. The emphasis should have been on saving the largest possible population of elms, many of which were 60 to 80 years old. It will be a long time before any new trees reach the size of these mature elms. A basic principle overlooked by many is that it is better to save what you have, what is already established, than hope that the newly planted will replace what is being lost.

# Dutch Elm Disease in Wild Elms

***Surprising to many, the wild elms are of value even in Minnesota***

Most of the information available on elms in Minnesota refers to trees located within communities. Little is known about our native so-called wild elm population.

Surprising to many, each of several varieties of wild elms are of value even in Minnesota, where they are not generally as large as in other regions of the country. The rock elm, for instance, was a highly desirable species that had historically been selectively harvested by farmers for buildings and later for ship building.

For better or for worse, there has also been an export market for the wood of various species of elm. It is widely suspected, in fact, that it was exported rock elm logs that carried the more virulent strain of the Dutch elm disease fungus to England about 1976. The transfer of this more virulent strain back to Europe resulted in catastrophic losses of elms in southern England. This aggressive strain then moved from there into mainland Europe, threatening more serious losses than previously encountered in those countries.

The slippery elm, also known as red elm, is another highly desirable exportable species. Red elm lumber is sold for veneer logs in the European market. Historically, many of these trees have been harvested in southern Minnesota. The wood of red elm is far more desirable and easier to veneer than the American or white elm. The American elm is, however, used for furniture.

Companies which export elm tree logs for use as veneer are especially concerned about the impact of Dutch elm disease, as it takes a long time to grow an elm to a size suitable for veneer.

## RURAL DATA RARE, DISEASE IMPACT EXTENSIVE

In spite of the value of wild elms, very little effort has been expended in dealing with Dutch elm disease in rural areas. Even the accumulation of data on rural tree losses is inadequate to be certain of what has happened. There is no doubt, however, that the losses have been substantial.

In 1975 and 1976 the incidence of Dutch elm disease in the rural areas was determined in evaluations of random plots scattered throughout Minnesota. The distribution of these plots was skewed, with more being in the southern sector than in the middle third of the state. No rural plots were established in the northern portion of the state because of the paucity of elms in groups suitable for a plot.

Losses to Dutch elm disease were substantial, and the peak losses in 1977 paralleled the urban pattern (Table 8). In the southern sector, the research plots established had tree counts ranging from 17 to 63. Only a few large trees over 60 cm (measured at a height 54 inches up the trunk) were present. Six plots were established in the central region, with number of trees ranging from 12 to 76. Again trees more than 60 cm were uncommon.

*Table 8. The incidence of Dutch elm disease in rural Minnesota in 1975-1977 was determined by tree counts in random scattered plots.*

| Southern Region: Year | Percent | Central Region: Year | Percent |
|---|---|---|---|
| 1975 | 5.7 | 1975 | 0.9 |
| 1976 | 15.0 | 1976 | 11.4 |
| 1977 | 73.0 | 1977 | 23.0 |

The losses in urban communities in the same regions were significantly less. The comparable losses in urban situations were 2.7 percent and 8 percent in 1975 and 1976 contrasted to 3.4 percent and 13.3 percent for rural trees.

In a separate study, 19 randomly located plots were defined in 1979 in a band running from north to south through the middle of the state. In the 1979 baseline examination, the percentage of diseased elms averaged 14.3. By 1981 that average had increased to 28 percent. Actual incidence of Dutch elm disease varied greatly between plots, ranging from none to as high as 90 percent. The losses were highest in the south and least in the central sector.

Between 1979 and 1981, the percentages of Dutch elm disease on farmsteads with elms, from Mankato to Tracy in southern Minnesota, increased from 88 percent to 94 percent. By 1983, nearly all of the elms on those farmsteads were estimated to be lost, and by 1985 it was thought likely that close to 90 percent of the wild elms over four inches in diameter were probably lost.

# Management of Dutch Elm Disease

***People proposing alternatives to sanitation were failing to understand the basic biology underlying the spread of the Dutch elm disease fungus***

From the very beginning of the impact of Dutch elm disease in the United States, professionals (i.e. scientists) and amateurs have competed in the search for a magic cure. Miraculous cures have been publicized to the extent that much of the "tried and true" basics of dealing with the disease have been shoved aside and even ridiculed. The unfortunate truth has been repeatedly supported by the failures of these "miracle" cures; the recommended control measures which are effective can be accomplished only with hard work and money.

## NO MAGIC BULLETS

People continue to search for that magic compound which will cure even diseased trees completely colonized by the fungus. Tremendous sums of money have been spent on fake cures, treatments which were known by those knowledgeable about tree diseases to be of no value. Often these cures, some of which receive national front page news coverage, are proposed by people who have little or no understanding of the fungus and the disease. Promotions by non-pathologists are not only publicized but are often also financially supported by the public.

The major attention that these magic cures often receive is to the detriment of continuing education of the public on the proven control program. Not only is money often spent foolishly but the treated trees are lost as well.

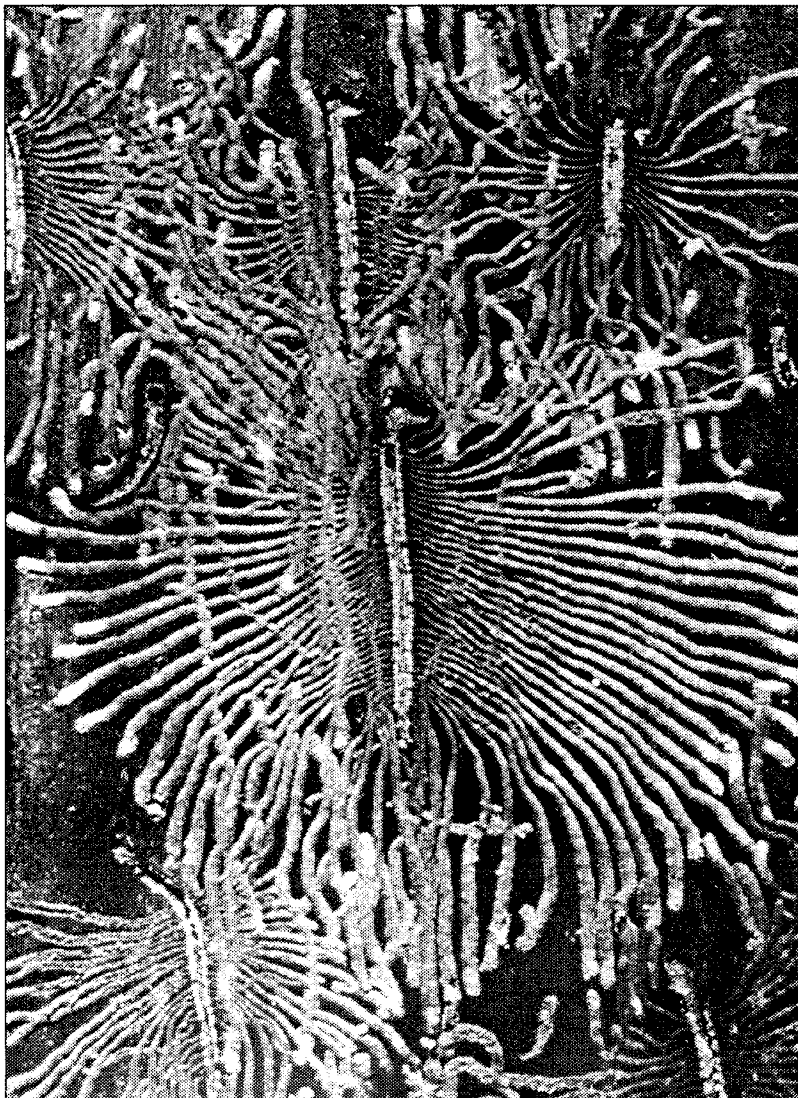
Despite all the efforts expended searching for an exciting new effective technique for controlling Dutch elm disease, the basic approach, known for years, remains the best. The simple answer to the control of Dutch elm disease is sanitation.

Sanitation includes detection and destruction of all dead and dying elm trees, be they American, red, Siberian, or any kind. The notion that Siberian elms are resistant, which they are, and thus do not serve as sources of infested beetles is nonsense. The idea that every tree had to be diagnosed in the laboratory before it could be condemned was expensive, delaying, and led to further spread of the fungus. The "pressures" brought to bear on behalf of some elms, because of their prominence or their ownership by a prominent citizen, were also disastrous to neighboring elms. Sanitation programs were constantly being blocked and slowed by individuals who proclaimed to be concerned about our environment.

Sanitation was further encumbered by the well-meaning Pollution Control Agency which prohibited burning, despite that being the most expeditious way to dispose of beetles and beetle environments. The efforts to slow Dutch elm disease would have fared much better and cost much less if burning had been allowed. Random uncontrolled burning was not what was sought. Supervised burning in prescribed locations would have provided great advantages to those fighting Dutch elm disease and any resulting pollution could have been considered a small price to pay. The permissible thousands of fireplace fires in a single evening in Minnesota's cities have far more impact on the environment than would have been created with the few fires that were foolishly prevented from being used to burn elm refuse piles.

One of the major metropolitan elm disposal sites was fortunate to have accidently gotten around that burning ban. It was a site designed to promote the utilization of the elm wood from removed trees. Logs, branches, and brush poured into the site in conformance with magnificent plans to salvage the quality logs for use in a variety of products. Unfortunately, the amateur managers of the operation found themselves inundated in acres and acres of elm debris with more coming faster than they could manage. At one point their equipment couldn't even move when it was in running order. Fortunately, on a day when the wind was blowing away from St. Paul and weather conditions were otherwise favorable, a fire started accidently.

What would have cost millions of dollars and taken too long for the



*Egg-laying galleries of the European elm bark beetle have a characteristic but macabre appearence. They run parallel to the grain of the tree, with the larval feeding tunnels at right angles to the main gallery. The beetle overwinters as larvae and emerges as an adult around June. A second generation can be produced by these adults in late summer or early fall, and in some years weather can permit even a third generation to be produced.*

operators of the site to process, was quickly gone. The mayor of St. Paul and the city's fire chief apparently decided it was safe to let the fire burn and better to save the money that would have been needed to put it out and to haul the debris to another location. The fire, which injured no one and had little impact on the environment, saved a lot of money. It was hard on bark beetles as well.

People proposing alternatives to sanitation were failing to understand the basic biology underlying the spread of the Dutch elm disease fungus. The fungus spores carried by the two beetle carriers of *Ceratocystis ulmi* are spores produced in the insect galleries and the fungus is introduced to the galleries by the female beetles as they lay eggs. Thus it made little difference whether a tree died of Dutch elm disease or was killed by an automobile, a girdling chain or winter injury. Any dead or dying elm could harbor beetles and the fungus.

In the early stages of the control programs the requirement that laboratory tests confirm that an elm tree had Dutch elm disease delayed removal of hazardous trees. In some cases the lab diagnosis was a month or more late. On other occasions the samples from a suspected tree were inadequate, and though the tree was infected the fungus was not isolated. Those trees remained to endanger all elms in their vicinities. Laboratory confirmation was not necessary because Dutch elm disease can be diagnosed accurately in the field.

Sanitation, in addition to detection and tree removal included separation of roots between infected and healthy trees, a technique often referred to as root barriers. With all the effort put into searching for a cure, practically nothing was done to develop a method of preventing movement of the fungus through common root systems. In some Minnesota communities, circumstantial evidence suggested that as many as 88 percent of all new cases of Dutch elm disease resulted from invasion through common root systems. The only known technique for disrupting these common root systems in cities was with the soil sterilant SMDC, but this method has not been well researched and doesn't always work.

One major Minnesota city discontinued placing barrier chemicals around diseased trees when a study showed that their techniques were ineffective. They were ineffective because they were improperly placing the barrier, with the chemical applied only from curb to sidewalk. The roots of the boulevard elm trees extended much farther and were actually fused in the front yards where no barriers were placed. Even with barriers placed all around the diseased tree, they sometimes failed because the roots were not killed at all the points of application or because the fungus had already moved into the adjacent tree. Mechanical barriers are not a reasonable solution because of buried utilities.

*Selective pruning, although expensive and labor intensive, can effectively extend the lives of some infected elms. Many of the successful chemical interventions may, in fact, be attributed as much to accompanying pruning as to the use of the chemicals.*

An important fact is that an elm infected through its roots can not be saved, but a beetle inoculated tree can be, through selective pruning, if detected early enough.

This other form of sanitation, pruning, can be practiced only in a small percentage of cases. Aside from cost, the major objections to using this approach on public property is that it is extremely difficult for city foresters to monitor individual trees, especially when losing thousands of trees per year. It is a viable approach, however, and elms can be saved very easily by pruning.

In University of Minnesota studies, over 95 percent of the diseased elms pruned experimentally have been saved. The technique prevents the fungus from entering the main stem and in turn the roots of that and neighboring trees. Many of the elms supposedly saved by injecting chemicals were probably actually saved by pruning, which is part of the recommendation in chemically treating diseased trees.

Additional control measures do exist, but all are secondary to sanitation. When DDT could be used, it did provide some additional protection to a population of elms. Meth-oxychlor, one alternative to DDT, does not persist on foliage branches and must be applied in the spring when weather conditions often limit spraying operations. It has not been part of control programs in Minnesota as it is not effective enough to justify the expense. Many people also objected to having their houses, cars, yards and children sprayed. Cities that had such programs abandoned them.

## ***SYSTEMIC TREATMENTS***

There is a long history of systemic chemical treatments for Dutch elm disease, some directed at the elm bark beetle, but most directed at the fungus pathogen. The earliest systematic attempts were at the Connecticut Agricultural Experiment Station at New Haven in the 1940s.

Effective systemic fungicides came along quite late in the epidemic. After some unsatisfactory results, research in Wisconsin and Minnesota finally determined that Arbotect is effective when used in sufficient amounts and when properly injected. Initially the insoluble form of benomyl was announced as an effective fungicide but its results were not impressive. Several publications developed by extension services described its use: the requirement for rapid distribution, the need for pressure equipment, and the technique for solubilizing the fungicide with lactic acid. Later benomyl was solubilized with phosphoric acid and the latter material, the most promising of this series, Lignasan BLP, was labeled for control of Dutch elm disease. Arbotect came a bit later.

Despite their efficacy for the control of Dutch elm disease, both Lignasan and Arbotect were labeled at rates far below what was needed for effective treatment, one-sixth the needed amount of Lignasan and one-third the amount of Arbotect. Initial injections were in the main stem above ground and later through severed roots. Best results were obtained by below grade or root flare injections which could protect elms for two years, and possibly even into a third season. Root flare injections have resulted in far better distribution of the chemical within the tree.

The products currently labeled and used in the United States are water soluble acid salts of two benzimidazole compounds developed in the 1970s. Measured in terms of long-term prophylactic effectiveness in the tree, Arbotect 20-S (thiabendazole-hypophosphite) is currently the product of choice by the professional tree care industry. The product also has a therapeutic effectiveness if the fungus infection is not systemic, the highest label rate is delivered uniformly to all parts of the tree, and the symptomatic parts of the tree are subsequently removed.

Current research at the University of Minnesota and Virginia Tech with a relatively new fungicide, called Alamo (propiconazole), although too preliminary to report, suggests that the product may be effective as a therapeutic treatment for diseased elms. Prophylactically, the product is completely effective against overland transmission in mature trees, at least for the short term (one season).

Despite this progress on the chemical front, the economics of fungicide injection are entirely against the process, except for trees of high value. At more than $10 per inch of tree diameter (measured at at a height 54 inches above ground) it is expensive and certainly not logical for entire populations of trees. Injection will also not work in elms infected through the roots or when the fungus has already become established in the main stem.

It is unfortunate that the majority of elms injected with system fungicides were improperly treated. Not only were the procedures a waste of money, but many homeowners, having invested several hundred dollars on the process to save their trees, argued that their elms should not be removed even though they constituted a hazard. The fungus and beetles profited as a result and the sanitation program lost ground.

While systemic fungicide injection was of some value when properly administered, there were many other proposed cures for Dutch elm disease which, in spite of newspaper stories and self supporting statements, were of no value. There have, in fact, been well over 500, and possibly as many as 1,000 suggested cures for Dutch elm disease. Often people became unbelievably enthusiastic before any substantive evidence on a treatment's effectiveness became available.

Many elms have been treated with substances never even approved as non-hazardous by the Environmental Protection Agency. Many which have had EPA approval, have erroneously promoted the impression that EPA approval also means that a proposed fungicide actually works as advertised. The EPA has always passed approval only on whether a compound is hazardous. The losers in these affairs have been the tree owners, paying out good money while still losing their trees.

Another negative attached to the proliferation of unproven and ineffective treatments has been how those failures delayed the introduction of an effective chemical control. Research at the Sault St. Marie Laboratory in Canada found that Dursban (chlorpyrifos) was effective in reducing populations of the native elm bark beetle, which is the primary vector in northern Minnesota and much of Canada.[2] But even with that evidence, it was several years before the use of Dursban was recommended in Minnesota. It has since become an important part of a control program, especially for northern Minnesota.

*Injection of dozens of biological and chemical compounds have been proposed as magic cures for Dutch elm disease. Several have been tried by researchers at the University of Minnesota, on the university's own trees. While a few of the compounds produce some degree of control, the overwhelming majority have been found worthless. Some can even be dangerous to the tree or the individual handling it.*

[2] Gardiner, L.M. and Webb, D.P., 1980. Tests of chlorpyrifos for control of the North American elm bark beetle (*Hylurgopinus rufipes* Eichh). Department of the Environment, Canadian Forest Service, Sault St. Marie Report O-X-311.

# Some Better Known Failures

***Minnesota seems to have been the target of many attempting to sell the latest cure for Dutch elm disease***

A city councilman of one Minnesota city once confidently informed the University of Minnesota forest pathologist that the answer to Dutch elm disease was the systemic insecticide Bidrin, and that for a bit more than a dollar a tree the elms could be saved. His authority was a story in *Readers Digest*. Bidrin, a toxic material, would be delivered in sealed plastic containers with recommended cautions of avoiding contact with the chemical. A user would have to guess the health of an elm to judge the amount to use. Too much would severely damage or kill the tree; not enough would fail to kill the bark beetles until after they had moved on and inoculated other trees. The University never recommended its use in Minnesota. Ultimately a brief news release by the U.S. Forest Service announced that Bidrin was not effective.

A more recent control candidate was the bacterium, *Pseudomonas syringae* which has been known for some time to inhibit the growth of many fungi. Many species of bacteria are inhibitory to fungi, but claims and publicity for this approach to dealing with Dutch elm disease went far beyond both the available data and the opinions of the people involved in its testing. Some of the promoters, overly anxious to solve the problem, suggested that a group of scientists could solve Dutch elm disease in two years if turned loose on the problem, and that the bacterium was one of the answers.

Influenced by early reports on its potential, people were anxious to obtain the bacterium and inject their trees. It was claimed that even a tree with 45 percent of its crown wilted could be saved. The statement was made "that the results are too good to be true." Publications offering data on the effectiveness of the bacterium were scanty, however, and it was difficult to determine just how well the bacterium performed, especially on mature shade trees. [3]

A major company became involved in the work on *Pseudomonas syringae* and invested resources to learn whether injecting the bacterium into infected elms would indeed save those trees. They also worked on related procedures for manufacturing the bacterium, storing it, and bioassaying trees that had been injected so as to determine whether the bacterium remained in the trees. There were also problems to overcome in selecting the correct strain of the bacteria, as only certain strains had a high level of activity against the particular fungus that caused Dutch elm disease. Although there were some reports indicating some reduction in disease symptoms in the year of injection, most of the treated elms did not recover and died. Enthusiasm for this control has disappeared.

The principle of using bacteria to reduce the activity and damage caused by a pathogen is, however, valid. Undoubtedly, in the future we will learn how to use living antagonists to control diseases such as Dutch elm disease, but considerable research on the subject is still needed.

Other suggestions for biological controls included using pheromones, a sex attractant, to draw the beetles carrying the fungus into traps containing cacodylic acid to kill them. The U.S. Forest Service ran major research projects in Colorado, Detroit and Minneapolis to evaluate pheromone traps as a way to reduce beetle activity in an area. In Colorado, entire cities were used to evaluate the effectiveness of these traps, with multiple rows of traps placed around the community to be protected. The researchers concluded that the system was only useful for monitoring beetle populations. The reduction in Dutch elm disease was not significantly better than in areas without traps.

Trees injected with cacodylic acid are killed by this arsenical compound, and beetles which are attracted to these trees will not survive. Another compound, potassium iodide, was also found to be potentially even more effective. A forest pathologist in Illinois demonstrated its value even before research on cacodylic was begun in Minnesota. But despite its potential, EPA approval of potassium iodide was never obtained and it has had only limited use in con-

[3] Frank Howard, a scientist at the University of Rhode Island had been quoted as early as 1960, in reference to an unidentified compound which he was investigating for controlling Dutch elm disease, that there were test results that "look almost too good to be true." Nothing came of his continuing research on that compound.

trol programs. It instead became an example of a potential research find which never progressed beyond publication of an academic paper: the bridge between research and application often is either not present, or cannot be crossed for any number of reasons.

Minnesota seems to have been the target of many attempting to sell the latest cure for Dutch elm disease. A product called "Elm Arrestor" was sold in at least four states, including Minnesota. "Elm Arrestor" actually, as far as we know, had different compositions over a number of years, and there was no data supporting the efficacy of any of its various formulations. At different times its active ingredients were mercuric chloride (.12 percent) and methyl alcohol (95.65 percent), or inadequate amounts of Arbotect.

Antibiotics called aureofungin and KT were tested in Georgia, Kansas, Kentucky and Minnesota. On the Minneapolis campus of the University of Minnesota, treated trees that were known to be infected with Dutch elm disease died. The value of these antibiotics has not been supported with data. Some of the same people involved with promoting the antibiotics later obtained EPA approval of a product labeled as Phyton-27, again with no data supporting its value for the control of Dutch elm disease.

There have been claims for a product called Fungi-sol [2-(2 ethoxyethoy) ethyl-2-benzimimidazole carbamate]. No data on its effectivness is known to have been published, and only the company's statement that the chemical is effective against Dutch elm disease is available.

In the early 1970s a product called "Treegard" was proposed as an answer to Minnesota's elm problem. The promoter stated that over 1,000 elms had been treated and every one of them had survived. This was followed by "Elm Guard" (sodium salt of 2, 2'-methylenebis (4-chlorophenol) [dichlorophenl] which was demonstrated to be ineffective.

In the mid '70s, the fungicide BRW-101, a derivative of vanillin 3-methoxy-4-hydroxy-5-chlorotoluene, was proposed for injection into trees with Dutch elm disease. The University of Minnesota injected 63 trees with this compound, again without any success in saving the trees.

Another material for injecting diseased elms was offered as M-62. Again, in spite of some positive statements about its ability to save elms from Dutch elm disease, there were no supporting data.

For many years copper nails have been recommended as the solution for many tree problems. Copper nails are actually toxic to the tree, and the copper is unlikely to be sufficiently distributed in the tree to be effective against a fungus. In fact, both copper and zinc nails have been promoted for the control of Dutch elm disease, though it's difficult to understand why people would expect four rows of nails at three-inch spacing at a convenient height to have impact on a fungus.

## OTHER PROPOSALS

An interesting approach to reducing beetle populations was suggested to be the parasitic wasp *Dendrosoter protuberans*, which supposedly will search out and parasitize larvae. These wasps were imported from France. The suggested plan was to release about 5,000, obtained from Michigan State University, along the Mississippi River. Rumors expanded that release to box-car size loads. The release is not known to have ever occurred. Where they were introduced in other parts of the U.S., it was found that the wasp parasitized larvae under thin barked portions of tree. The important overwintering population in Minnesota survives under thick barked portions of the tree. The idea has not led to any major known effort in control here or elsewhere.

Another unusual proposal came from a florist and an allergist in Michigan. Hearing that the fungus kills by causing the tree to plug its own vascular system, they developed a decongestant liquid which they suggested could unplug the tree's water transport system. They did receive national news coverage for their idea.

A dentist recommended mineral supplements, so the tree would be healthier. The Dutch elm disease fungus will, however, do as well in a healthy as in an undernourished tree. A medicine man from a South Dakota reservation suggested that St. Paul pay him $1 million to inject their elm trees with an unspecified ancient Indian medicine. From New Ulm, Minnesota, came a suggestion to use a mixture of carp, seaweed, and other ingredients. And "pyramid power" would cause bark beetles to veer away from elms, it was suggested, if a properly constructed pyramid was placed in the stand of trees to be protected. Another proposal prescribed seven applications of giberrellic acid mixed into other chemicals, along with background music and a high frequency emission from a tweeter. Supposedly two cities had contracted to have over 150,000 trees treated by this process.

# The Future for Elms in Minnesota

***Our tendency has been to acquiesce to ease and convenience, which means we've planted easily grown, easily transplanted species***

Minnesota has not lost all of its elms since Dutch elm disease was first found in the state more than 30 years ago. While it is likely that many elms in forested areas of the state will be lost, including those of any substantial size, elms are a tenacious species and will always be with us. We just won't have as many of the large specimens. The cities, however, face a different scenario, and any community that has good judgement will be able to keep many of its elms.

A reasonable program of management can continue to maintain low losses and preserve a substantial portion of our shade tree elms. The management program is a wise investment because the absence of any effort to stop Dutch elm disease will result in dead trees which still must be removed.

An argument can be made that a community actually saves money by keeping the elms it has for as long as it is able. Cities should appreciate that it takes decades for newly planted replacement trees to reach the stature and beauty of our existing residual elms. And the new trees will have their own problems, including susceptibility to their own diseases. Finally, for the very reason that so many elms were planted in the first place, we have to acknowledge that few other tree species are as beautiful and acceptable in as many respects for a shade tree.

The choice of replacement trees is surprising in some respects. It's understandable that we are planting more ash (26 percent) trees than any other single species because this tree is cheap to produce, easily transplanted, and, when young, reasonably attractive. But, older ash are not so attractive; they lose their leaves early in fall and are late producing leaves in spring. Some varieties of ash have had a high rate of mortality, and we now have two serious diseases of ash to contend with, ash yellows and Verticillium wilt.

Another 38 percent of our new replacement trees are exotics which are not entirely suited for this part of the country. They are often prone to disease and insect problems. Why plant untested exotics when there are dozens of native species? The answer in part is that Minnesotans are not growing all of their own trees. A high proportion are being shipped in from other parts of the country.

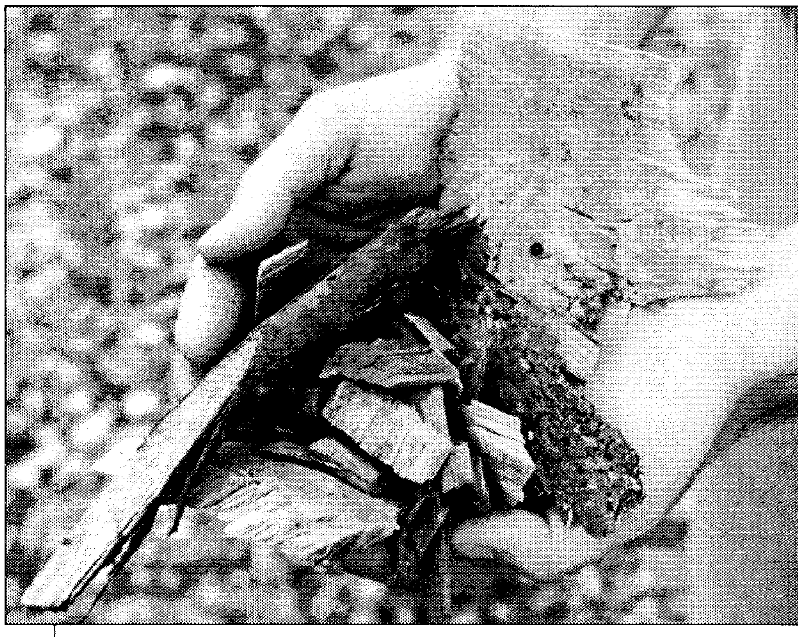
Even species native to Minnesota are not necessarily satisfactory if the seed from which they are grown comes from a distant tree. Red maples, for example, grow over much of the eastern United States, from Maine to Florida. But maples evolved and adapted to Florida are not likely to survive Minnesota's climate. Other species that are being planted also have their own disease problems. Potentially, up to 20 percent of the honey locusts being planted can be infected by a lethal canker disease.

## WHY NOT RESISTANT TREES?

Nothing has been said about resistant varieties of elms. When Dutch elm disease was causing tremendous losses in Minnesota in the 1970s was not the time to develop resistant elms, a process which takes years. The Dutch have been at it for six decades with only minimal success. They are still searching for that elm they need.

Minnesota's reforestry recommendations were based on planting trees which we know are resistant to Dutch elm disease. These include maples, hackberries, oaks, and birches to mention a few. There was no question about these trees being resistant to Dutch elm disease and they were suited to our climate.

The resistant elms which were available in the early years of the Dutch elm disease epidemic, were exactly that, resistant but not immune. More important they were both not well suited to Minnesota and not comparable to the native elms in stature and beauty. Siberian and Chinese elms have resistance to Dutch elm disease fungus but are undesirable species because they are subject to winter injury. A not entirely facetious recommendation by this author has been that these trees be pruned at the ground line. It is not an uncommon scene in Minnesota to see rows and rows of dying Siberian elms which had been planted as windbreaks along roads and around farmers' fields. Once established they can become a problem because of their heavy seeding habit.



*Elm's of any variety do little more than harbor the fungus and the beetles which spread it. The only appropriate use for so-called "resistant" varieties may be as firewood or mulch chips.*

Now is the time to choose carefully and wisely as we select the tree species we plant to renew our urban forests. Thus far this has not been done. Our tendency has been to acquiesce to ease and convenience, the translation of which means we've planted easily grown, easily transplanted species. Unfortunately this has led to planting too many ash trees, too many honey locusts, and too many little leaf lindens. There are other choices.

Is there a place for the elm in the future? The answer is a very definite yes. There are resistant elms more recently developed which have more desirable characteristics and these are now being evaluated in Minnesota. We should consider keeping the American elm in our landscape. As Dutch elm disease becomes less abundant, and possibly if the nonaggressive strain becomes more common (in 1977 only 8 percent of 1,124 isolates were nonaggressive), the American elm might be replanted in some locations. It should never be planted as abundantly as was done by our forefathers, but it should be a part of our landscape plans.