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MANAGEMENT OF DUTCH ELM DISEASE

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Dutch elm disease (DED) was introduced into the Eastern United States from Europe about 1920. Since 1950, the disease, transmitted by bark beetles, has spread rapidly throughout the Midwest. Today, it is found throughout the U.S. and in eastern Canada as far north as the natural range of the elm.

The few native stands of elm still in Michigan occur mainly in the Upper Peninsula. Elms found in the Lower Peninsula are mostly those which were planted as street and shade trees in urban areas. They are the scattered trees that escaped the disease, or the 50-70% of the original elm population in those areas which maintained control programs.

Although only a fraction of the original elm population remains, DED is still a major concern among many urban residents and those involved with the care and maintenance of city trees. This bulletin presents guidelines for extending the life of the remaining elms. It should be noted that DED losses are now occurring and will continue to occur. Thus, when we speak of DED control, we are referring to the *reduction* of the rate of loss, not to a complete elimination of the disease.

Cause and Transmission of DED

Dutch elm disease is caused by the fungus, *Ceratocystis ulmi*. The tiny spores ("seeds") of this fungus germinate in the water-conducting tissues of the living elm tree. As the fungus grows, it causes the tree to form gums which plug the water-conducting tissues (Figure 1). This condition causes the tree to wilt and die. Many trees die in the same season that infection occurs—some die within a few weeks. Only a few live longer than the second or third season and even fewer recover completely.

All elms are susceptible to DED, with the American elm being the most susceptible. Chinese and Siberian elms are highly resistant to the disease, although individual trees have died from the disease in Michigan. Several hybrid elms, produced both in this country and in Europe, have been advertised as immune or resistant to Dutch elm disease. None of these hybrids are actually immune, but some of them do show resistance approaching immunity. The Asiatic species and many of the hybrids grow faster than our native elms. Some

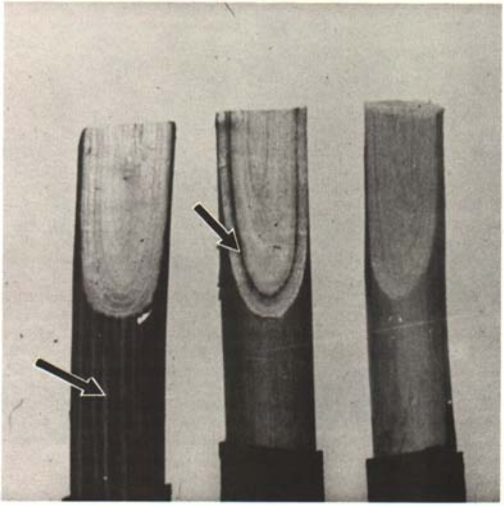

Fig. 1. Typical appearance of branch pieces from a Dutch-elm-diseased tree. The discoloration appears as long brown streaks in the longitudinal sections (left, arrow); as a ring of brown discoloration in the diagonal cross-sections (center, arrow). This brown discoloration is located in the wood just beneath the bark. (Note healthy stem at right.)

selections, however, are not winter-hardy in Michigan or are very susceptible to diseases other than Dutch elm disease.

When adult bark beetles leave diseased elm trees, fungus spores are likely to cling to their bodies. These spores enter healthy trees through the feeding wounds made by the adult bark beetles. Wounds are usually made in the crotches of 1- and 2-year-old twigs of healthy elm trees (Figure 2).

Many Michigan communities have continued to lose elms even though they have carefully followed the conventional control measures of sanitation and spraying. Most of this loss can be attributed to the fungus passing through natural root grafts between diseased and nearby healthy trees. The extent of this type of transmission varies with the spacing distance between trees. Elms over 40 feet apart are seldom united by a root graft, while trees less than 20 feet apart are frequently connected.

Symptoms of Dutch Elm Disease

The most noticeable symptom of Dutch elm disease is the wilting of one or more branches of the infected trees. The wilting leaves become yellow and, later, turn brown when dead. Branches with dead, brown leaves may hang among the green foliage of healthy branches, a further sign that the tree may have the disease.

Does Your Tree Have DED?

There is only one way you can be sure that a tree has Dutch elm disease. Diseased twigs and branches must be examined for the fungus by a plant pathologist using laboratory methods.

Fig. 2. Smaller European elm bark beetle feeding in a twig crotch. Spores of the fungus are carried from diseased to healthy trees during this feeding period.

Here's what you do:

1. Cut six twigs about 7 inches long and ½ to 1 inch in diameter from the diseased branches of each tree. (See Figure 1 for the appearance and description of Dutch-elm diseased twigs and stems.)

2. Mark the twigs from each tree.

3. Wrap and bind securely in a suitable cardboard box for mailing. **Do not send material that has been dead for some time or which does not show the discolored ring under the bark.**

4. Send all samples for Dutch elm disease testing to the Dutch Elm Disease Identification Laboratory, Michigan Department of Agriculture, Laboratory Division, Lansing, Michigan 48909.

If you have further questions about sending in samples for identification, check with your county agricultural agent.

Note: It is very important that you mail the samples immediately after collecting. Delay in getting the twigs to the laboratory only makes the problem of identification harder.

A report on the sample will be mailed to you in about 14 days. If the disease is found in the sample, your tree or trees should be destroyed as soon as possible.

Beetles that Transmit the Disease

In the U.S., the fungus which causes DED is transmitted largely by two species of elm bark beetles: the smaller European bark beetle, *Scolytus multistriatus* (Marsham); and the native elm bark beetle, *Hylurgopinus rufipes* (Eichhoff). In the lower two-thirds of Michigan, the smaller European bark beetle is the msot common vector and usually displaces the native species where they initially occur together. This beetle was first introduced to the U.S. from Europe in 1909 and has now been found in every state except Florida, Hawaii, and Alaska. The native species is more prevalent in Michigan's Upper Peninsula.

Beetle Description

Although similar in size, 1/8" long (2-3.5 mm), both the European and native elm bark beetle are easily distinguished (Figure 3). The European species has a shiny two-toned appearance: the wing covers are dark, reddish-brown while the head and thorax region (prothorax) is black. In contrast, the native elm bark beetle is uniformly gray-to-brown in color, with coarsely punctured depressions on the hind wing covers. Silhouettes of the adult beetles are also unique. The European beetles have a concave posterior while the native species has a more rounded or dome-like outline.

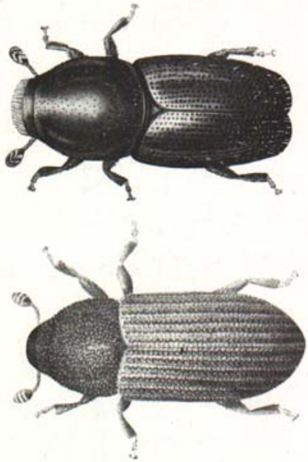

Fig. 3. The smaller European elm bark beetle (top) is from 1/12 to 1/8 inch long. The native elm bark beetle (bottom) is about 1/16 to 1/12 inch long.

Life History

The smaller European elm bark beetle overwinters as a larva beneath the bark of dead or weakened elms (brood wood). Adult beetles emerge through small holes in the bark beginning in late May and early June. They immediately fly to living elm where they feed in the crotches of 2- to 4-year-old twigs (Figure 2). The beetles may be covered both externally and internally with as many as one million spores of the sticky DED fungus (Figure 4).

Although healthy elms are preferred for feeding, beetles usually breed in dead or dying elm wood with intact bark. The adults of the smaller European elm bark beetle bore through the bark and construct grooves, for their eggs, parallel to the grain of the wood (Figure 5). Upon hatching, the legless, white, grub-like larvae feed in the inner bark (phloem) and wood surface. Their feeding creates mines which radiate somewhat perpendicularly from the egg gallery leaving an elliptical pattern (Figure 4).

Complete development from egg to adult takes about 6 weeks. A second generation of adult beetles begins to emerge in mid-July and continues through September (Figure 6). However, disease transmission by these late season beetles is insignificant

Fig. 4. Enlarged photograph of diseased elm wood on which fruiting bodies of the fungus have developed. White globular areas contain spores in a sticky matrix.

compared to infections caused by the spring generation of beetles.

The native elm bark beetle has a similar life history but with several important exceptions. Like the European species, it may overwinter as larvae in brood wood and emerge in June and July. However, some adults may emerge in late summer and early fall and fly to healthy elms to overwinter in tunnels formed in the thick bark of the lower trunk. These adults then emerge in April and May, about 2 weeks before the smaller European elm bark beetle adults appear, and feed through the bark (not in the crotches) of healthy branches 2 to 4 inches (5 to 10 cm) in diameter. Adults then fly to dying elm wood to breed. In contrast to the European species, native females form egg galleries that run perpendicular to the grain and larvae tunnel along the grain creating a butterfly-shaped pattern.

There are also significant differences in the breeding habitat preferences of these beetles. The European bark beetle occurs more frequently in elms along city streets, yards, and parks, while the native species prefers shaded habitats, especially woodlots and forested areas. When both occur on the same tree, the sunny portions of the tree are colonized by the European beetle and the shaded limbs and lower tree bole by the native beetle. Usually, the native species is displaced by the more aggressive European species.

Fig. 5. Enlarged photographs of wood infested with the smaller European elm bark beetle. Note that the egg galleries are constructed WITH the grain. This insect is the most important carrier of Dutch elm disease.

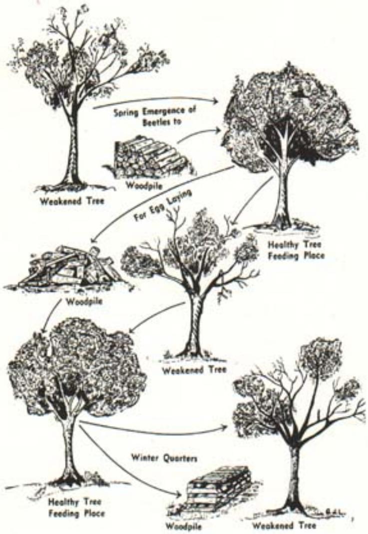

Fig. 6. This shows how bark beetles, by their feeding habits and in the normal life cycle, spread Dutch elm disease. As the beetles move from infected wood into healthy trees, they carry the fungus spores with them. DESTROY BREEDING SITES to help control Dutch elm disease!

Control of Dutch Elm Disease

There is no one single control program which is correct for all elms. There are, as we will see, different degrees or levels of control. But the initial question which must be answered is, "How valuable is that elm tree to the owner and what is the owner willing to spend on control?" The important point is to match the level of control to the value of the trees and your financial resources. What is right for one city is not necessarily right for another.

The control of DED can be achieved through: a community program and a program for the individual home owner. We will list various management techniques and show how to combine these methods to meet the needs of different types of owners.

For control, it is important to understand the life cycles of the fungus, its transmittal, and the growth habits of elm. As mentioned earlier, the fungus survives and proliferates in diseased, dying and recently killed elm trees. The two elm bark beetles which transmit DED also prefer these trees as sites for overwintering and brood production. When adult beetles emerge in the spring, they fly to healthy elm trees to breed. Finally, elm trees planted in close proximity often form root grafts which may connect several trees underground.

Control of DED, (reduction of the rate of tree loss) may involve many steps: 1) sanitation, 2) root graft prevention and destruction, 3) tree maintenance, 4) insecticide sprays for beetles, and 5) systemic fungicides.

1. Sanitation

Sanitation is the most important and effective step in preventing the buildup of elm bark beetle populations. Any elm wood with intact bark, e.g. firewood, tree stumps, broken or dead limbs, and trees killed by disease, drought or storms are ideal breeding habitats for bark beetles. Consequently, all recently dead or dying elm wood must be destroyed to reduce beetle populations and the probability of disease transmission. Proper disposal consists of removing all bark and burning, chipping or burying wood more than 4 inches in diameter. Major sanitation efforts should be directed at larger wood.

Since beetles are capable of flying several miles, sanitation must be practiced on an area-wide basis, i.e., entire municipalities, to be effective. Sanitation alone will not prevent the disease from spreading but it will reduce the infection rate and provide time for tree replacement.

Several communities with good sanitation programs are holding their annual losses to 1-3%. As the wild elms around these communities are eliminated, the degree of control achieved by sanitation alone is increasing. Certainly, the greatest return per dollar comes from those spent on sanitation. Limbs and trees killed by the disease (or any other cause) in urban or suburban areas must be removed sooner or later because of their liability to property and people. Prompt removal not only solves this problem, but is also the most important step a community can take in reducing DED.

To achieve a high degree of control through sanitation, all trees must be checked for DED and the presence of elm bark beetles at least twice a year—late June and again in late July or early August. Three surveys are much better. Destroy all diseased, dead or beetle-infested wood located in the first or second survey within 14 days. Destroy similar material found later in the summer before May 1 of the following year. If elm wood is saved for firewood, remove the bark to prevent the bark beetles from overwintering in it.

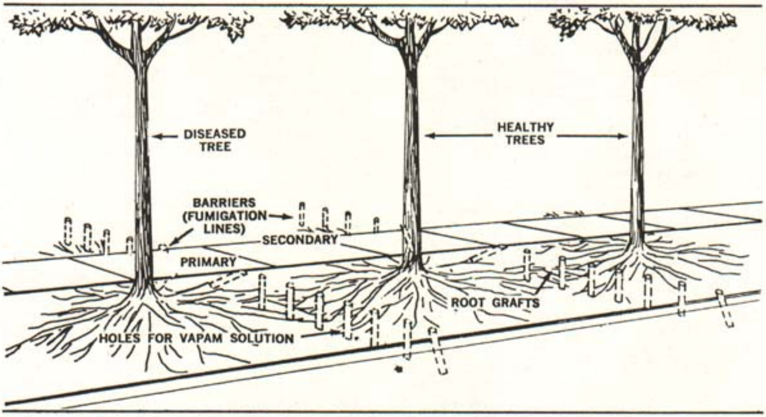

Fig. 7. Proper Vapam application is shown. The holes at the street and on either side of the sidewalk should receive extra doses to insure root kill under these obstructions.

2. Destruction of Root Grafts

Studies have shown that over 50% of the trees lost, particularly in communities with good sanitation and bark beetle control, become diseased via root grafts. Any community seriously interested in controlling the disease should destroy any potential root grafts between diseased and healthy trees by mechanical or chemical means.

Where elms are planted close (within 40 feet or less of each other) consider thinning the stand during normal tree maintenance operations. Remove trees that have poor vigor. This action will have several benefits: 1) lower vigor trees are more attractive to beetles, thus, more prone to attack by DED, 2) the remaining trees will benefit by the reduced competition for light, nutrients and water, and 3) many root grafts will be destroyed, which may help slow the spread of DED through the remaining stand.

Destruction of root grafts can be best accomplished with the soil sterilant Vapam. This fumigant is also known as VPM, SMDC, and sodium N-methyldithiocarbonate. This chemical has been found to kill elm roots in a limited zone thus providing a method for chemical root pruning. Apply Vapam immediately after a tree is diagnosed as having Dutch elm disease if it is within 50 feet of a healthy elm. If trees are less than 20 feet apart or if a diseased tree has advanced wilt symptoms, it is necessary to treat at two sites: between the diseased and the first healthy-appearing tree, and between the first and the second healthy-appearing tree. This is advisable because the fungus may have already passed from the diseased to the first healthy-appearing elm before Vapam was applied.

Place the line of treatment so as to kill the roots of the two adjacent trees that are likely to be grafted. This can best be accomplished by applying the chemical in an unbroken, straight line equidistant between the diseased and adjacent healthy elm (Figure 7). However, the line of holes should be at least 10 feet from the trunk of the healthy tree. If sidewalks, hedges, or other plant material prevent application in a straight line, then apply the chemical in a T-shaped or L-shaped pattern.

Drill holes approximately ¾ inch in diameter, 15 to 20 inches deep, and 6 inches apart. Fill holes with Vapam, diluted one part Vapam to three parts water. Seal each hole carefully by tamping to prevent gas dissipation. A circle of grass 3 to 6 inches in diameter is usually killed around the point of infection. After 4 to 6 weeks, the dead spots can either be resodded or reseeded. Allow two weeks after treatment before removing the diseased tree.

3. Tree Maintenance

Two recent studies on pruning diseased wood have shown that 30 to 60% of the diseased trees can be saved, at least temporarily. Pruning must be done promptly (within 1 to 3 days of first symptoms). The greater the development of the disease within the tree, the less chance of success. Any trees with multiple infections or with more than 10% of the foliage showing symptoms are poor candidates for sanitary pruning. If the pruning cut is made at least 6 feet below the last visible discoloration in the wood, the chances of successfully eliminating the disease are doubled. Sanitation pruning is probably only justified where the disease is restricted to a small portion of a specimen tree with high value. Communities with a good integrated control program should *not* allow pruning to weaken their sanitation program.

All shade trees should be on a regular maintenance program which includes fertilization, watering during droughts and removal of dead or dying branches. Note, however, that removal of healthy branches during the summer may **increase** the incidence of Dutch elm disease. This type of trimming is employed by certain communities once every 5 to 10 years, to shape trees and remove branch obstructions above streets, houses, wires, etc. As a result, trimmed trees are attractive to the small European elm bark beetle which invades the main trunk to lay eggs. Beetles introduce the fungus and, while the trees may appear vigorous in the fall, trees wilt and die rapidly the following spring.

4. Insecticide Sprays

The application of contact insecticides to control bark beetles has been one of the main tactics of DED programs for many years. A major problem is coverage of all bark surfaces, especially twig crotches, with enough material to kill feeding adults for an extended period of time. There is current speculation whether adequate insecticide coverage of all bark surfaces is possible, using conventional application techniques. A beetle spray program may add little to DED protection compared to what can be achieved through a good sanitation program.

Methoxychlor is the only contact insecticide currently registered for control of elm bark beetles as a dormant or summer spray (see Table 1). When both beetle species are present, thorough coverage of all bark surfaces is necessary. Where only the smaller European species occurs, coverage of small twigs (1 to 4-year-old wood) is critical. When the native species is the primary vector, sprays of Dursban (chlorpyrifos) applied to the lower trunk (basal 3 to 4 feet) in the fall or spring will control adult beetles.

Table 1. Methoxychlor* Sprays for Elm Bark Beetle Control.

Type of Spray	DORMANT RATES**		SUMMER RATES	
	% Solution***	Amount/	*Solution 50 ft. tree	Amount/ 50 ft. tree
Hydraulic	2% (8 gal./ 92 gal.)	20-30 gal.	1% (4 gal./ 96 gal.)	20-30 gal.
Mist blower	12.5% (50 gal./ 50 gal.)	2-3 gal.	6% (24 gal./ 76 gal.)	2-3 gal.

**25% Methoxychlor EC (emulsifiable concentrate) containing 2 lbs AI/gal.*

***Apply before bud breaks in late April when temperature is at least 35° F and rising.*

****Percent concentrate solution is determined by the volume of liquid concentrate (actual ingredient) divided by the total finished volume of liquid multiplied by 100. For example, to make a 2% Methoxychlor solution, mix 8 gal. of the ED [2 gal. AI (25% to 8)] with a 92 gal. of water for a finish spray of 100 gal.; to make a 12.5% solution, mix 1 gal. of 25% Methoxychlor EC with 1 gal. of water or 50 gal. of the EC [12.5 gal AI (25% of 50)] mixed with 50 gal. of water for a finished spray of 100 gal.*

Several types of application equipment can be used with varying effectiveness for dormant sprays. Hydraulic sprayers provide good coverage throughout the crown but require considerable time and labor. Helicopter application provides good coverage of the upper crown and may be less expensive when large numbers of trees are involved. Ground-operated mist blower effectiveness tends to be limited to smaller trees since coverage of the upper crown is often spotty. In all cases, the addition of a 5 to 10% solution (by volume) of a horticultural grade oil (80 or 90 sec.) to the spray mixture will help prevent damage to automobile finishes.

5. Systemic Fungicides

Arbotect 20-S and other closely related materials are currently registered as an aid in DED control. Only trained, licensed pesticide applicators are permitted to use these chemicals, and then only as directed. Although there is still disagreement among researchers concerning the effectiveness of systemic fungicides, they are clearly the least effective and most expensive method of DED control. In addition, presently registered methods of injection can cause severe physical injury to the tree. Systemic fungicides are not a cure-all and should never be used as a substitute for other control methods.

Summary

We have discussed the various methods of DED control. How can these methods be integrated into a successful DED control program, first for a community and secondly for an individual elm owner outside a control area?

DED can be controlled best on a community-wide basis. The necessary technology has been available for at least 20 years and many municipalities have controlled the disease using this knowledge. Exactly what can and should be done depends on the value of the elms and the economic resources of the owners. The bare minimum that any group or individual should do is sanitation, for these funds must be spent sooner or later to remove the dead trees. Frequent and thorough surveys followed by prompt removal of diseased trees will save money as well as elms.

The second level of control is to add root graft control, methoxychlor application and good tree care. If properly done, this 4-prong attack should keep annual losses to less than 2%. The use of all four steps is essential if DED losses are to be held to a minimum. If a community does not have the financial resources to apply all controls to all their remaining elms, they should evaluate their elms and concentrate a complete control effort on the most beautiful and desirable trees. All control measures should be used to save this limited number of trees.

The individual who owns an elm outside of a control area is going to have an extremely difficult job in preventing DED mainly because no meaningful sanitation program can be carried out. However, disease control is possible for the few elms which remain alive after most of the surrounding elms have died. Nature has already conducted her own sanitation program so that the number of elm bark beetles and the amount of fungal material have been greatly reduced compared to the epidemic years. The least expensive program, and perhaps as effective as any other program under these circumstances, is to watch the tree very carefully for any symptoms of DED. At the first signs of wilt, prune the diseased portion. An owner with greater economic resources and a valuable tree should consider spraying with methoxychlor. While the degree of control achieved with methoxychlor would not be as great as when used in a community program, its use would decrease the risk of DED. If more than one tree is involved and they are less than 30 feet apart, root graft control will be necessary. This could be done even before any of the trees become infected to be sure the grafts are non-functional.

While the odds are against an individual saving any particular elm, those owners who have the resources and inclination can save some of these elms or at least prolong their life.

Other methods of combatting DED have been suggested or are under investigation. DED resistant elms are a possibility and some selections have already been released. If a truly disease-resistant tree with desirable horticultural traits could be developed, this would be the ultimate in DED control as, once established, no additional expense would be required. However, no such tree exists and it is doubtful if it will exist in the near future. Recent research has shown the fungus which causes DED to be very variable with some strains much more pathogenic than others. The Dutch who worked to develop resistant trees for 60 years have found that some of their most promising selections are susceptible to these new strains of the fungus. There are many other problems involved in the development of disease resistant trees such as susceptibility to other diseases, especially phloem necrosis, and winter hardiness.

Occasionally, one reads about other DED cures such as zinc nails, kerosene, epsom salts or some other mysterious potion for which the creator claims great things. Many of these materials have been carefully tested as control agents in federal or state laboratories. *None* have significantly reduced DED and none are registered for use in Michigan.

Hopefully, we have learned a lesson from DED, diversity. Never again should we allow 50 to 90% of the shade trees in a community to be of a single species. While man may like to have a whole avenue or subdivision of one type of tree, this is extremely hazardous because nature can retaliate dramatically and destructively against uniformity. Many mid-western communities lost nearly all their shade trees in a decade or less because nearly all their shade trees were elms. Much of nature's strength lies in her diversity. Rarely does a single factor such as disease wipe out a species in undisturbed nature. It is only when man enters the picture and unifies the environment that the stage is set for an epidemic. Most serious plant diseases are host specific. Therefore, even if a serious pest does attack, only a small portion of the total need to be lost if the original risk was spread among many species.

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