Dutch Elm Disease

PP-324 (Revised)

Robert W. Stack , Professor Plant Pathology
Dean K. McBride , Extension Entomologist
H. Arthur Lamey , Extension Plant Pathologist

Introduction

Dutch elm disease was first found in the United States in Ohio in 1930. It has now spread throughout North America and has destroyed over half the elm trees in the northern United Sates. The disease has been reported in all states except the desert Southwest.

Dutch Elm Disease (DED) was first found in North Dakota in 1969 in Mandan. It was discovered in eastern North Dakota in 1973. By 1987 it had become established throughout eastern and central North Dakota and reported from all counties except those in the extreme northwestern part of the state.

Dutch elm disease is caused by the fungus *Ophiostoma ulmi (syn. Ceratocystis ulmi)* which is transmitted by two species of bark beetles or by root grafting. The American elm, *Ulmus americana*, is the most seriously affected of all elms. The Siberian elm, *Ulmus pumila*, (colloquially called "Chinese elm" in North Dakota) is tolerant but not immune to the disease.

Symptoms

The observable symptoms and the progression of the disease differ among trees which are inoculated through beetle feeding and those which are infected through root grafts. Trees infected by beetles first show wilting, curling and yellowing of leaves on one or more branches in the upper portion of the tree (Figure 1). Large trees may survive and show progressively more symptoms for one or more years. Trees infected through root grafts wilt and die rapidly; this frequently occurs in the spring soon after the trees have leafed out and progresses from the base of the tree upward.

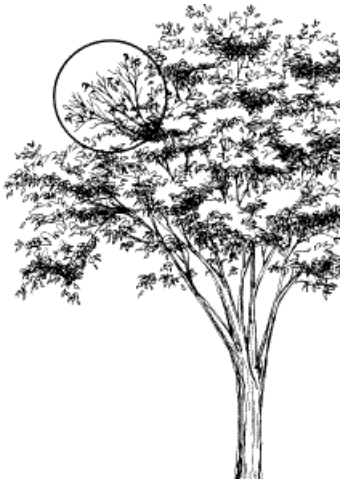

Figure 1. Pattern of wilting in American elm caused by Dutch elm disease.

The symptom pattern is different for infections resulting from feeding by the native elm bark beetle and the smaller European elm bark beetle. This is related to the preferred feeding habits of the two species. The smaller European elm bark beetle feeds in small twigs, usually high in the crown, while the native elm bark beetle bores under the bark of branches 2-4 inches in diameter to feed.

Inoculations from the smaller European elm bark beetle result first in yellowing and wilting of small branches, high in the crown. As the infection progresses downward, more and larger branches are affected. A complete sequence of foliar symptoms occurs; yellowing, then wilting branches can be seen in succession. When infections of this type occur, streaking will be found in the wood of small branches and even twigs. Recommendations for therapeutic pruning or therapeutic chemical treatment of infected elms assume infection from smaller European elm bark beetle feeding is being treated.

When inoculation has been done by the native elm bark beetle, a different pattern of symptoms appears and there are important differences in the feasibility of control measures. Because the native elm bark beetle feeds in bark of branches 2-4 inches in diameter, DED infections start as much as 10-20 feet farther down into the crown than with smaller European elm bark beetle infections. From this infection site, the fungus moves down the branch and, to a lesser extent, upward. The first symptom usually seen is wilting and browning of an entire branch or segment of the crown. There may or may not be yellowing of leaves preceding this wilt. Such early symptoms may closely resemble those resulting from a broken branch. While streaking is present in the larger branch where inoculation took place, many of the smaller wilted branches (1-2 inch diameter) and twigs may not show streaking in the wood. This absence of streaking in branches of the size normally submitted for laboratory diagnosis has caused some confusion in the past, as these non-streaked branch samples will not yield the DED fungus when tested.

In addition, because of their position, the infections arising from native elm bark beetle inoculations have a head start in spreading through the tree. Frequently, by the time first symptoms are noted, the fungus has already reached scaffold branches or the main trunk of the tree; this renders therapeutic pruning impossible and chemical therapy unlikely to succeed. Most of the beetle-involved DED infections in North Dakota cities have been the native elm bark beetle type. For this reason, use of therapeutic treatments for infected trees often is not effective and is not recommended.

Trees infected with Dutch elm disease usually develop brown streaks in the sapwood of wilting branches (Figure 2). Cross sections of infected branches will show brown streaks in the outer wood in spring; in summer they will show a single ring of brown dots in the wood. Trees infected through root grafts or lower trunk infection do not show these symptoms in the branches but will show streaking in wood of the trunk if a chip or wedge is removed.

Once the fungus is established within a tree, it spreads rapidly via the water-conducting vessels. The tree forms gums within these vessels in response to the presence of the fungus, causing the tree to wilt and eventually die.

Since the causal fungus fruits in or under the bark, the only positive method of diagnosing Dutch elm disease is laboratory isolation of the fungus from living infected branches.

Figure 2. Discoloration of the sapwood caused by Dutch elm disease.
(Click here for black and white photo, 43KB)

Elm Bark Beetles – Carriers of the Fungus

Two kinds of bark beetles attack elm trees (Figure 3), the smaller European elm bark beetle *(Scolytus multistriatus)* and the native elm bark beetle *(Hylurgopinus rufipes)*. They are important elm pests because they carry the Dutch elm disease fungus as they move from infected breeding sites to feed on healthy elm trees. The European species is the more important carrier where it occurs, but while both species are present in North Dakota, the native elm bark beetle is much more common and important in the spread of DED.

Figure 3. Smaller European elm bark beetle (top) and native elm bark beetle (bottom).
(Click here for black and white photo, 15KB)

SMALLER EUROPEAN ELM BARK BEETLES pass the winter as larvae in the bark. When warm weather comes in the spring, larvae complete their growth and transform to pupae and later to adult beetles. The adults begin emerging about the middle of May through holes that they make in the bark (Figure 4). They continue to emerge during the warm months. The adults feed in the crotches of living elm twigs and, if carrying the Dutch elm disease fungus, may introduce it into healthy elm trees. Later they bore through the bark of dead or dying elm trees or recently cut elm logs. They form galleries in the inner bark, grooving the surface of the wood parallel with the grain.

Figure 4. Emergence holes made by adults of the smaller European elm bark beetle in elm bark. Natural size.
(Click here for black and white photo, 23KB)

The female places her eggs in niches along the sides of the gallery. Larvae that hatch from these eggs feed in the inner bark and the surface of the wood and construct mines that extend at an angle from the egg gallery (Figure 5a). When full-grown, larvae build cells in the bark and there transform to pupae.

The cold North Dakota winters kill off most of the smaller European elm bark beetles. Those that survive do so only in protected spots, **especially home firewood piles**. It is for this reason that elimination of elm firewood is such an important factor in DED control.

NATIVE ELM BARK BEETLES pass the winter either as larvae in elm bark or as adults. Most of the adults overwinter in tunnels they have made in the thick bark at the base of healthy elm trees. They begin to appear in May and make their egg galleries in the same kind of elm material as do the smaller European elm bark beetles. However, these galleries extend across the grain of the wood (Figure 5b) instead of parallel with it and can be distinguished from the egg galleries of the smaller European elm bark beetles. An egg gallery of the native elm bark beetle usually consists of two branches diverging from the point where the parent beetle penetrated the bark.

Figure 5a. Egg galleries and larval mines of the smaller European elm bark beetle on surface of wood, one half natural size.
(Click here for black and white photo, 49KB)

Figure 5b. Egg galleries and larval mines of the native elm bark beetle on surface of wood. Three-fifths natural size.
(Click here for black and white photo, 47KB)

The native elm bark beetle feeds in bark of small to medium-sized branches – often those 2-4 inches in diameter. They bore into the bark and tunnel along the bark-wood interface, scoring the wood as they feed. If a beetle is carrying spores of the DED fungus, it will be introduced into the wood of the branch and a DED infection may be the result.

In arid, windy sites the beetles may prefer to feed on branches of smaller, understory trees rather than the larger, more exposed elms. When this happens, such smaller trees may become infected while larger, overstory trees are not. This pattern has been observed repeatedly in the woody draws and sloughs along the Missouri River Valley.

Bark Beetles and Dutch Elm Disease

Unless elm bark beetles are associated with Dutch elm disease, there is usually little need for control measures as the beetles' feeding and boring activity does not harm trees that are in a vigorous condition. Once DED becomes established in a location, better control of bark beetles is an integral part of a DED management program.

Spores of the Dutch elm disease fungus are carried on the bodies of these beetles and deposited in egg galleries and tree wounds. European elm bark beetles transmit the fungus by feeding on small twigs. Native elm bark beetles introduce the Dutch elm disease fungus when making feeding tunnels in the bark. After feeding, bark beetles seek breeding sites under the bark of dead or dying elm trees or recently cut logs (Figure 6). The DED fungus develops in the galleries formed by the bark beetles. There it produces spores which are picked up by the young beetles when they emerge.

Most emerging beetles feed on healthy elms within 1,000-1,500 feet of where they hatched. However, beetles may rise to altitudes of several hundred feet and be carried by air currents for many miles.

Figure 6. Drawing shows how the bark beetles, in their normal cycle, spread Dutch elm disease. Spores of the fungus are carried by the beetles as they move from infected wood to feed on the new twig growth at the tops of healthy trees.
(Click here for black and white drawing, 17KB)

Control Measures

Effective disease control programs should be considered on a community-wide basis. Dutch elm disease control involves two different but related programs: (1) community-wide sanitation programs designed to reduce the level of elm bark beetles (principal carriers of the Dutch elm disease fungus); and (2) prevention of the spread of the disease through natural

root grafts from infected trees to adjacent healthy trees.

There is no way to eliminate Dutch elm disease once it begins; control programs have as their object the management of the disease so that losses are spread out over a long period, minimizing the impact of the disease.

Insecticides

As mentioned before, the adult native elm bark beetles bore into the thick bark of large trees in the fall to overwinter. Because most of the elm bark beetles which survive the winter in our climate do so only near the base (lower 4 feet) of large trees, it has been possible to treat such trees with insecticide to reduce beetle populations. Such treatments are feasible both for communities and for individual homeowners, although individual action is of limited value. Some cities, such as Winnipeg, have included Dursban® insecticide spray of tree bases as part of their regular DED control program. It is especially useful for treatment of problem areas, such as areas near river corridors where bark beetle populations are high and disease-carrying beetles emigrate in the fall from infected native stands to residential areas.

The insecticide Dursban® (2E and 4E) is registered for control of overwintering native elm bark beetles. Dursban® 4E should be used at the rate of 0.5% active ingredient, which is 1 1/3 fl. oz. (2 2/3 tablespoons) per gallon of water. Dursban® 2E is to be used at the rate of 2 2/3 fl. oz. (5 1/3 tablespoons) per gallon of water. The bottom 9 feet of the trunk should be sprayed to wet the trunk thoroughly but do not spray to runoff. Special care should be taken to clear away grass and weeds from the base of the trunk to get good coverage of the root flare. Sprays can be applied from spring to early fall and are most effective if applied by the end of August. An early spring (late March – early April) treatment may offer some additional protection. Dursban® is a restricted use pesticide and is to be applied by certified pesticide applicators only.

Sanitation

A year-round community sanitation program is the key to slowing the spread of the disease. Since elm bark beetles breed in dead elm wood with intact bark and in weak or dying elm trees, the first steps toward control of the beetle involve the destruction of all dead or dying elm wood present in the community. This includes Siberian elm as well as American elm.

Any dead, dying, or weak elm trees or elm wood with bark firmly attached can serve as a breeding site for beetles. This includes limbs hanging on trees that may have been damaged by storms (hail, wind, etc.) the previous season, trees that are very old or weakened by pests, and fresh elm firewood. Branches less than 4 inches in diameter are generally not a threat because the beetles do not survive in them even if colonized. Firewood is an exception, however, because firewood piles are often in protected locations and partially covered with snow.

The chance of root graft spread of Dutch elm disease to adjacent trees increases in direct proportion to the length of time an infected tree stands before removal. Immediate removal (within two weeks) of newly infected trees will substantially reduce the number of trees infected by root grafts. Immediate removal should be a routine procedure where it can be accomplished.

Sanitation alone will not stop the spread of the disease, but it will tend to stabilize its spread and prevent epidemic outbreaks. The true value of a good sanitation program is that it allows time for a replacement program so that a community doesn't lose all of its trees at once. Replanting new trees of other species can then proceed on a gradual basis.

The value of a good sanitation program is often underestimated because some people believe that, "The elms will die anyway." Although this may be true, the rate of dying can be dramatically affected. The experience in Illinois is an example. When DED was first found in 1950, certain communities established excellent sanitation programs. Some communities that maintained these programs still had 75 percent of their elms 25 years later. In contrast, communities with no sanitation programs had lost all of their elms.

The value of boulevard elms is great and maintaining them should be a high priority because of their beauty as well as for three economic reasons. First, property values are enhanced by shade trees, and their loss results in lowered property values. Second, trees provide shade and evaporative cooling which reduces cooling costs in summer. Third, even the bare branches of trees in winter effectively reduce winter wind velocity and so reduce winter heating costs.

Firewood Control

In cities with municipal forestry programs where standing dead trees and fallen logs are routinely removed, elm firewood with intact bark may play a major role in overwintering survival of elm bark beetles. Because the interior of a firewood pile offers a protected environment, beetle survival may be higher than in standing trees or fallen logs. It appears likely that elm firewood piles are the only important survival site for the smaller European elm bark beetle in North Dakota cities.

Effective reduction of elm firewood cannot be achieved by ordinance alone – it requires the cooperation of an informed public. A few elm logs secreted away by one homeowner who does not understand the importance of the problem can undo all attempts at thorough sanitation and watchful disease surveillance for an area of several city blocks.

In firewood-poor areas like most of North Dakota, high heat value elm wood is a resource which many feel should not be wasted. The desire to use wood from dead and dying elm trees is a legitimate one and must be weighed against the need to control Dutch elm disease – also a legitimate concern. Some communities have obtained de-barking equipment which permits both of these goals to be achieved.

Failure to effectively control presence of bark-on elm firewood will doom any municipal control program, regardless of how well its other aspects are carried out. No American city has ever been able to control DED if it was unable or unwilling to control elm firewood. If a community is not prepared to enforce tough firewood control as part of its tree ordinance, then the other parts of a DED control program are of questionable value.

Information on identification of elm wood is provided in the circular **"Identifying Elm Firewood"** (Minnesota Tree Line No. 25) available from county offices of the NDSU Extension Service or from the NDSU Ag Communication Distribution Center.

Root Graft Transmission

Spread through natural root grafts has accounted for a majority of new cases of Dutch elm disease each year in some Midwestern cities.

Elm trees which are growing close together (within 50 feet) over a period of years form root grafts. If one of the trees becomes diseased, the DED fungus will be transmitted along an entire street by moving directly through the root system into adjoining healthy trees. In other words, disease in just one tree in the row could cause infection and death of the remaining trees. Immediate removal of infected trees (see sanitation) reduces the chance of root graft spread by getting rid of the infected tree before the Dutch elm disease fungus reaches the roots.

The only way to prevent transmission through the roots is to create a barrier between diseased and healthy trees by severing or killing those roots between the trees. This can be done without harm to the healthy trees either by mechanical trenching or through the use of chemical barriers, which have been found to be quite effective in some situations.

Mechanical trenching for disruption of root grafts has the advantage of being quick and effective if the machinery is available and no pipes, underground cables or pavements are encountered. Two types of equipment are commonly used for me chanical root disruption – ditch diggers or trenchers and the vibrating plow. The trench should be as narrow as practical and can be refilled immediately. Many cities and towns own or have access to small self-powered trenchers (such as "Ditch Witch") which will cut a trench 24-30 inches deep. Homeowners using such equipment (often from rental stores) should exercise **EXTREME CARE** not to contact buried power cables or gas lines. Severe injury or death could result

To be entirely certain of disruption, a trench depth of 48 inches is needed, but most roots are much nearer the soil surface and trenching to a depth of 24-30 inches is often adequate. The deeper trenching may require specialized equipment. A 30-inch trench cut immediately is probably better than a 48-inch trench delayed for days or weeks while waiting for the special machine.

A fumigant, sodium N-methydithiocarbamate (SMDC) sold under the trade names of Vapam and VPM, has been found effective as a chemical barrier. The chemical fumigant is dangerous and should be applied only by trained applicators. Homeowners should consult their city forester or a reputable, trained arborist.

Chemical Treatment

Systemic fungicides (Arbotect) can be injected into the trunk or root-collar of the affected tree. Follow label directions. These fungicides should be used only by trained arborists; in many cities arborists must be licensed by the city forester to permit this work.

Because slogans such as "Save the Elms" have wide popular appeal, chemical tree treatment is sometimes offered by untrained or unscrupulous individuals in competition with reputable trained arborists. Check out the individual offering treatment with your local Chamber of Commerce, Better Business Bureau or local forester before agreeing to any treatments; obtain a written description of all work to be done and get any guarantees in writing.

Do not use systemic fungicides with highly alkaline water. If the level of calcium is very high, or if the hardness is over 10 grains per gallon, the fungicide may form a precipitate rendering it ineffective and possibly damaging the tree. Much of the water in North Dakota exceeds this level of hardness. If the local water is too alkaline, use distilled water, deionized water, or bottled spring water.

Therapy of Infected Elms

Many municipal tree ordinances require removal of Dutch elm disease-infected elms regardless of therapeutic treatment; check your local tree ordinance before arranging therapeutic treatment. "Curing" Dutch elm disease is a popular slogan in advertisements, but a true cure can be obtained only in a small proportion of cases under very specific conditions. Even when these specific conditions are met, a substantial proportion (20-30 percent) of infected elms fail to recover and are eventually lost.

Therapeutic tree injection is generally only effective where less than 5 percent of the crown of the tree shows symptoms. The symptomatic part of the tree should be pruned out promptly as it will not recover. Ideally, the infected branch should be removed 10 feet below where streaking of the wood ceases.

Most DED infections in North Dakota arise from inoculations by the native elm bark beetle. For that reason, most DED infected trees will already show more than 5 percent crown involvement by the time first symptoms become evident. At that time, in many such trees, the fungus will have already invaded the main branches or trunk – as evidenced by streaking in the wood. For these reasons therapeutic treatment will be expected to fail in many cases and cannot be recommended in North Dakota.

Therapeutic treatment of trees infected through root grafts has never been successful and cannot be recommended under any circumstances. Community-wide chemical therapy should **never** be attempted. Such a program cannot be justified either economically or biologically. A few communities have tried this approach and all have failed to arrest the disease and have seriously compromised their overall DED control program in the process.

Protective Treatment of Healthy Elms

Preventive injection with currently registered fungicides will require retreatment every one to three years to maintain the protective effect. Trunk or root collar injections injure the tree and the cumulative effect of repeated injections may damage the tree directly or lead to severe wetwood or other infection. Homeowners wishing to use preventive fungicide injection should contact a reputable, trained arborist or their city forester or state district forester for information.

The most effective chemical currently available is Arbotect. It has undergone extensive testing. Used at the high rate (12 fl. oz. per 5-inch trunk diameter) it gives three seasons of protection. Other products appear on the market from time to time. Most have received less rigorous testing; none has been shown to be as effective as Arbotect at the high rate (three-season protection).

By 1987 it was apparent that preventive treatment with Arbotect at the high rate ("Minnesota 3X" rate, or 12 fl. oz. per 5-inch trunk diameter) every third year was effective in reducing risk of DED infection and caused no long-term damage to most American elm trees, providing label and application procedures are carefully followed (See the circular **How to Inject Elms With Systemic Fungicides**).

Precautions in Handling Pesticides

Handle pesticides and solvents carefully. Pesticides are poisons. Follow directions on labels exactly and take all

precautions listed. The solvents are flammable and their fumes may be toxic. Keep them away from fire. Do not inhale the fumes or spray. If you spill any of the chemical on the skin, immediately wash with soap and water.

Do not let the spray get into bird baths or fish pools. Do not let it form puddles beneath the trees or along street curbs where birds may come to drink. Keep children and animals away when spraying. Do not contaminate streams or ponds. Keep stored chemicals out of reach of children, animals, or birds.

Sampling Procedures

An accurate and efficient laboratory diagnosis of trees suspected to have Dutch elm disease is important. Several diseases affecting trees in North Dakota cause symptoms similar to those caused by Dutch elm disease. Among the more serious are Verticillium wilt, Dothiorella wilt, and wetwood.

Wetwood

Wetwood disease is caused by a bacterium which lives in the heart of the tree. Its growth results in pressure (up to 40 pounds per square inch) buildup inside the tree. This internal pressure causes oozing of sap from wounds and branch stubs. This sap is quickly colonized by yeasts and molds as it runs down the side of the tree, giving rise to the name "slime flux." In dry seasons this flux may appear as a whitish stain. Wetwood infection is found in nearly every elm. When it is severe branches may wilt and die and young trees may be killed. These symptoms resemble those of Dutch elm disease. A laboratory test is required to confirm the presence of Dutch elm disease.

Sampling

The wilting of one or more branches of a tree is generally an indication of disease. For sampling, six diseased but alive twigs, about 6 to 8 inches long and 1 inch in diameter should be cut and identified with the tree (Figure 7). The presence of the DED fungus can be determined only by a plant pathologist using laboratory techniques. Submit twig samples to the North Dakota State University Plant Diagnostic Laboratory through your county agent, state forester, or city forester. Place samples in a clean plastic bag and label them clearly. See the section on symptoms. If no streaking is found, sample larger and not smaller branches.

In cases where the entire tree has wilted or is nearly dead, it is possible to take samples from the main trunk. These can be chain saw wedges or ax chips. If ax chips are taken, be sure that the chips include wood, not just bark. Make sure that the wood shows dark discolored streaks in it.

Figure 7. Sample for laboratory diagnosis of Dutch elm disease.
(Click here for black and white photo, 57KB)

Alternative to Planting Elms

The value of Dutch elm disease resistance in American elm is of special importance. At present all species of elm hardy in North Dakota are more or less susceptible to Dutch elm disease. Several Dutch elm disease-tolerant American elms and hybrid elms have been found and may be available in the nursery trade. These include Delaware #2, Jacan, L'Assumption, Sapporo Autumn Gold, American Liberty, and Urban. Their winter hardiness has not been determined in North Dakota.

Siberian elms are not immune to Dutch elm disease but they generally show less severe symptoms and are not quickly killed. They do become infected and can act as a source of Dutch elm disease infection for neighboring American elms – they can act as the "Typhoid Mary" of Dutch elm disease.

It is best to plant a mixture of other trees with American elm, preferably mixing species within blocks or plantings.

You can plant the following tree species instead of elm or in mixed plantings with elm: green ash, common hackberry, basswood, soft or silver maple, bur oak, Russian olive, black walnut or flowering crabs. Distinctions and limitations of these trees are offered in Extension Bulletin No. 13, **Trees and Shrubs for North Dakota**.

Individual Citizen Responsibility

1. **See that your elm trees are kept in good, healthy condition by pruning, fertilization and deep watering during periods of drought.**
2. **Control other pests that may weaken your trees.**
3. **upport community interest in a Dutch elm disease control program.**

Remember, your trees are an important community asset. Trees, like anything else, need periodic maintenance in order to keep them performing well. What would your community be without them?

Guidelines for community tree management, model tree ordinances, and data on costs and benefits of Dutch elm disease control for community programs are available from North Dakota State University.

PP-324 (Revised), Reviewed July 96
