

Elm disorder: Dutch elm disease

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Dutch elm disease is a fatal fungus disease attacking American elms. The fungus is spread by European and native elm bark beetles and by root grafts (the growing together of roots of adjacent trees.)

Control emphasizes sanitation (the removal of dead elm wood and diseased elms), prevention of root grafts, and insecticide control of the bark beetles. Systemic fungicides provide some additional protection and curative treatments for individual high value elms.

For preventive control and curative treatment measures to be effective, it is vital to understand how these measures work, to know how Dutch elm disease spreads, to be able to recognize initial symptoms of the disease, to know which trees may respond favorably, and how to make treatments properly.

Spread

Dutch elm disease is caused by a fungus, *Ophiostoma ulmi*, which invades the water-conducting vessels of American elms and causes vascular wilt—that is, the pathogen clogs and plugs these vessels causing the trees to wilt and die.

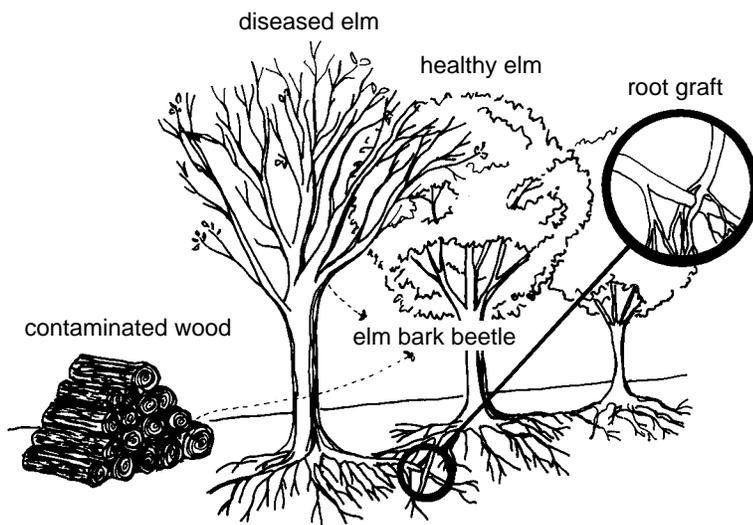
The fungus is spread initially over distances by elm bark beetles which emerge from diseased wood—each beetle is covered externally and internally with as many as one million spores of the sticky fungus. When the beetles feed on healthy trees, these spores get into the vascular system of the healthy tree, infecting it.

Once a tree is infected with Dutch elm disease by beetles, the fungus can spread to adjacent elms through connecting roots.

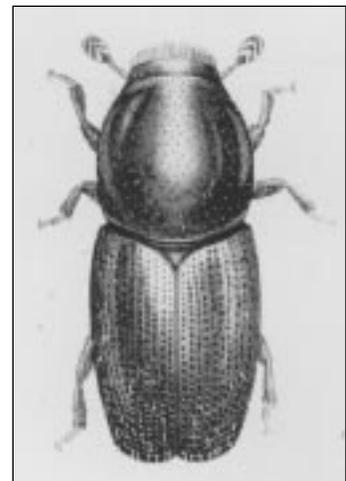
European elm bark beetle

The smaller European elm bark beetle (*Scolytis multistriatus*) is the most common carrier in the southern half of the state. The adult beetle is dark brown and approximately $\frac{1}{4}$ inch long. It feeds and reproduces only on elms. These beetles spend the winter as larvae just beneath the bark of recently dead or weakened elm wood (brood wood). Adult beetles start emerging from the brood wood about mid-May and continue to emerge during the warm months. Over 85% of the beetles emerge during early June when the elm is most susceptible. (Emergence and susceptibility occur somewhat later in northern Wisconsin.)

After emerging from brood wood, the adults feed in the small crotches of living elm twigs. Any fungal spores on their body enter the elm, germinate, become established, and eventually kill the tree.



The two ways Dutch elm disease spreads: from diseased wood to healthy trees by elm bark beetles, and from diseased trees to adjacent healthy trees through connecting roots (root grafts).



European elm bark beetle.

After the beetle feeds, it seeks more brood wood where it bores beneath the bark and lays eggs in an egg gallery which runs parallel to the grain of the wood. Beetles can contaminate brood wood with the fungus even though the tree did not die from Dutch elm disease. Therefore, when the next generation of beetles emerges, their bodies may also be covered with spores. Thus, all elm wood must be disposed of properly, regardless of its cause of death. Several thousand beetles can emerge from one heavily infested log.

There is one full first generation and one partial second generation of the European elm bark beetle each year. While those emerging in late summer are not as harmful as the spring crop, they do cause some late-season infection and they certainly increase beetle and fungus populations.

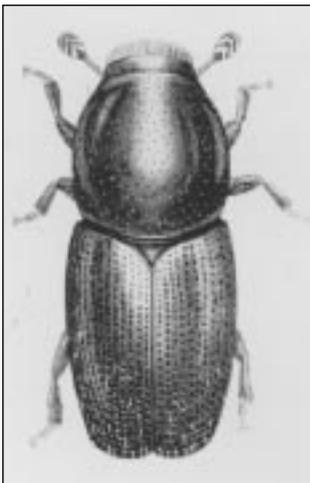
Native elm bark beetle

The native elm bark beetle (*Hylurgopinus rufipes*) is dark brown and approximately ¼ inch long. Its life cycle is similar to the European elm bark beetle's, but with some important exceptions. While some of the beetles overwinter as larvae in brood wood, others emerge from the brood wood in the fall and spend the winter as adults in shallow channels burrowed into the bark of healthy trees. In the spring, the native elm bark beetle feeds directly through the bark of larger twigs and branches—but rarely in twig crotches. Egg galleries in brood wood run perpendicular to the grain. This difference helps identify which beetle is present and is important for determining the proper treatment or the proper timing for sanitation to be completed (summer for native elm bark beetles; before May 1 for European elm bark beetles).

Native bark beetles are the predominant species in the northern half of Wisconsin. They are generally not as active or as explosive in population potential as the European elm bark beetle.

Root graft spread

Spread of the disease through root graft is a major cause of lost elms along city streets and other areas where elms grow near one another. Once a tree becomes infected by beetle feeding, it poses a serious threat to neighboring elms. Since Dutch elm disease is a vascular disease, the fungus moves through connecting roots (root grafts) into surrounding healthy elms as a diseased elm dies.



Native elm bark beetle.



Egg galleries of the European elm bark beetle run parallel with the wood grain.



The egg galleries of native bark beetles run across the wood grain. The fungus (enlarged) grows abundantly in the galleries. Beetles are easily contaminated by these sticky spores.

Large elms within 30 to 50 feet of each other (or even further apart in the case of huge elms) have a 75% chance of becoming infected through root grafts unless preventive treatments are administered. The closer trees are and the older they are, the more likely root grafts are to occur. One or several neighboring elms may become infected the same season, depending on the extent of grafting. Prompt removal of diseased elms generally will not prevent spread through the roots because the fungus is already within the root system before the infected tree can be removed. In many localities, infection via root grafts is considerably greater than by beetles. Thus, root graft control can be as important as beetle control.

Contaminated equipment

The disease might be spread by pruning healthy elms with contaminated equipment; although not likely. Try to avoid this possibility by using clean equipment and by not pruning elms in the summer.

Symptoms

Symptoms vary according to the season when infection occurs and whether the infection takes place from beetle feeding or root grafts. There are both internal and external symptoms. The symptoms must be recognized promptly and accurately so that proper and prompt action can be taken—such action depends on when and how the infection occurred.

External

Symptoms of infections caused by beetle feeding vary somewhat from tree to tree, but typically start in one or a few branches in the upper crown of the tree. Leaves on affected branches usually turn light green or yellow, then turn brown rapidly and curl up. They may remain attached to the branches for a while before dropping. Use binoculars to distinguish initial Dutch elm disease symptoms from those caused by broken branches.

The disease may spread rapidly throughout the tree, or it may take several years for the tree to die with just a few branches dying at a time. Some trees, in fact, may appear healthy for a time after the first symptoms have appeared. Occasionally the leaves are dwarfed and stunted.



Disease often spreads from tree to tree along one side of the street through connecting roots.



Holes in the bark produced by the emerging beetles.

Elms infected through roots may show symptoms the same season that the neighboring elm became diseased by beetle feeding. Quite often, however, symptoms don't appear until the next season and occasionally not for 2 years. Though you can't always distinguish symptoms of root grafted infection from those caused by beetle spread, the lower branch sprouts along the side of the trunk nearest the neighboring diseased elm generally show symptoms first. Suspect root graft spread when trees die successively in clusters—for example, trees die along one side of the street while those on the opposite side remain healthy. Connecting roots or graft infections rarely cross under city streets. Root-infected trees usually die more rapidly than crown (beetle) infected.

Late-season infection often develops slowly the first year, appearing as general yellowing which can be confused with normal fall coloration. Such trees generally leaf out the following spring, then wilt suddenly and dramatically.

Internal

Internal symptoms are quite helpful in field diagnosis of the disease. When the bark is peeled from wilted branches, the wood beneath appears light to dark brown, either in streaks or in solid patches. In cross section, the browning may appear as a series of dots in the outer ring, or the ring may be completely brown. Don't confuse such symptoms with the rather common discoloration of the central core of twigs and branches.

If the internal discoloration does not appear in the wilted branch area, examine the wood of branches or trunk below wilted twigs. With root-transmitted infections, the trunk wood beneath the bark on the side toward another diseased tree often shows discoloration much earlier and more intensively than the same area does with beetle feeding infection.

Laboratory confirmation

External and internal symptoms are often considered sufficient evidence of Dutch elm disease in areas where the disease is prevalent. In fact, prevention of spread through root grafts or systemic fungicide should be started at the first sign of infection without waiting for laboratory confirmation. But other diseases occasionally cause similar symptoms.

Confirmation of the disease is usually possible by laboratory culturing of the fungus. The Wisconsin Department of Agriculture, Plant Industry Laboratory, 4702 University Avenue, Madison, Wisconsin 53705, will process specimens submitted from June through August. Confirmation is sometimes easier with isolations made in early summer.



Early symptoms of Dutch elm disease often appear in small branches as yellow or brown leaves. Treating the disease at this stage gives the tree the best chance for survival.

Take three sections of small branches $\frac{1}{2}$ – $\frac{3}{4}$ inches in diameter and about 6 inches long from newly wilted branches. Select samples that show internal discoloration. (Only rarely can the fungus be isolated from branches that don't have internal discoloration.) Wrap them to prevent drying and send in immediately along with the appropriate information.

While laboratory isolation and identification of the fungus provides positive confirmation, a negative report does not always mean the tree is free from the disease. Occasionally the organism escapes detection in the laboratory. It is difficult to isolate during the latter part of the growing season, usually after August 15.

Control

Municipal programs

The primary emphasis in control is upon preventive action through complete municipal programs including:

1. Destruction of beetle brood wood.
2. Early detection and initiation of treatments.
3. Prevention of spread through root grafts by prompt treatment and severing root grafts.
4. Protection of high value elms using systemic fungicides.
5. Prompt treatment of very recently diseased high value elms with a fungicide if recovery can be expected and it will not affect the sanitation program.

Before starting a control program, each governing unit should determine the value of their elms and decide what level program is feasible. Options range from simple sanitation programs where elm numbers and values are low to complete municipal shade tree programs where elms are more abundant and trees represent a greater asset to the community.

No municipality can afford to ignore the problem on the assumption that the disease will not destroy their elms, or that it is cheaper to ignore its effects. Control programs should hold annual loss rates to 5 or 6% of the elm population. This will help a municipality to reforest and spread out tree removal and replacement costs.

Competent city foresters or officials are needed to oversee control programs, and they need rigidly enforced ordinances to make such programs effective. Certified commercial arborists can serve private citizens or can be retained on a part-time basis by smaller communities.

In addition to elm protection, municipalities need to emphasize maintenance and care of trees other than elms and to have tree planting and replacement programs using diverse adapted tree species.



The brown discoloration of the wood just beneath the bark in the three branches is typical of internal symptoms of Dutch elm disease. The sapwood of the two healthy branches at the right appears white or light green in color.

Destroying beetle brood wood

Remove and dispose of all diseased elms and all elms killed or seriously weakened regardless of cause. Elm wood may be chipped so none remains with sufficient bark to serve as brood wood for beetles. If chipping is not possible, diseased elm should be burned (where permitted) or buried in a landfill. If elm wood is to be used for firewood, the woodpile should be covered and sealed with clear, heavy plastic from April 15 through July 15 to destroy beetles within the wood. To prevent tears in the plastic, place old tires or burlap sacks between the wood and plastic. Seal edges of the plastic under a layer of soil. Sealing firewood under plastic is usually necessary only the first year because the bark loosens and becomes unsuitable for brood wood.

Where the European elm bark beetle is the primary disease carrier (especially in the southern half of the state—check brood wood for larval galleries parallel to the grain of the wood), remove and dispose of trees by May 1 of the year following infections. This will kill the beetles which all overwinter in brood wood. Municipalities should try to remove diseased trees by April 1 in case there are unforeseen delays. Moreover, removal of private elms is often required by local ordinance after detection to maintain municipal surveillance. Municipalities may remove the major branches of diseased boulevard elms during the summer the disease is detected, but leave the trunk and scaffold branches through the fall and into the winter. These “trap trees” attract large numbers of beetles. These trees are then removed before May 1, thereby destroying much of the overwintering population.

Where the native elm bark beetle is the primary disease carrier (northern half of Wisconsin), remove brood wood in the summer to kill those beetles already in the brood wood and to prevent adult beetles from finding brood wood. If removal is delayed, most of the beetles will emerge and fly to healthy elms to overwinter.

Elm tree pruning

It is important to keep elm trees pruned so that large dead or weakened branches in otherwise healthy trees do not become beetle brood wood sites. Prune in the winter while trees are dormant. Do not prune elms in the summer—such trees often attract beetles, substantially increasing chances for infection.

Early detection

Early detection of diseased trees followed by prompt and complete treatment is essential if adjoining elms are to be saved. Ground observations by city crews, sometimes supplemented by private citizens, mail carriers and other municipal employees can be successful in spotting diseased trees. Helicopters have been used for initial symptom detection, especially in June and early July when most symptoms are first apparent. Examine trees frequently in June, July, and August and know whom to contact for immediate treatment if symptoms appear.

Insecticide application

Spraying elms with an insecticide does not prevent Dutch elm disease. But municipalities with relatively few elms or those with both sanitation and root isolation programs can reduce the rate of new tree infections by spraying with insecticide to reduce the spread by beetles. Insecticide spraying without sanitation and diseased root isolation programs is of questionable value.

Methoxychlor can be used to control European elm bark beetles. It may be applied once in the spring when temperatures are above 40°F. Apply as close to bud swelling as possible to ensure residual protection through peak beetle activity in June. Use an emulsion preparation especially manufactured for Dutch elm disease control.

Mist-blower application is preferred to hydraulic spraying where possible. For mist-blower application use a 12½% concentrated spray—mix 1 part methoxychlor 25% emulsifiable concentrate with 1 part water. Use 2–3 gallons of the mixture per 50-foot tree. Only thoroughly sprayed trees will be protected from beetle feeding.

Chlorpyrifos can be used to prevent native elm bark beetles from overwintering in uninfested trees. Apply to the bottom 9 feet of trunk according to label directions.

To reduce the chances of killing fish, do not spray trees near ponds or streams. Avoid spraying if winds exceed 5 miles per hour as unwanted drift and poor deposit on trees result.

Preventing spread through roots

Spread of Dutch elm disease through root grafts can be prevented by mechanical separation (cutting of roots by trenching between diseased and healthy elms). Simply removing infected trees promptly does not necessarily prevent spread of the disease to adjacent trees through connecting roots.

Early detection of the diseased tree followed by prompt and complete treatment by certified arborists is essential. Do not wait for laboratory confirmation. Removal of diseased trees should be delayed for 10 days following root graft treatment.

Where a row of trees exists, as along a boulevard, an additional barrier should be placed between the first and second healthy tree. Such a barrier is of value if the disease has already moved into the first apparently healthy tree, but has not yet become apparent.

Systemic fungicides

These chemicals are injected into elms to combat the disease-causing fungus. They may be used preventively to reduce risk of infection to the healthy elm. They may also be applied curatively to certain elms showing early stages of disease development. The following important considerations will help you choose trees most likely to benefit and inject them properly for satisfactory results.

1. Tree selection. Systemic fungicides will not save trees infected by or likely to be infected by root graft transmission. Look for proximity to diseased elms and at how symptoms develop. See the section on symptoms for more information.

Trees diseased through multiple beetle infections within a season are less likely to survive than those battling single infection sites.

Consequently, elms in "sanitized" communities are better candidates simply because there are fewer infections that must be stopped by the fungicide.

Rock elms and trees smaller than 5 inches in diameter may be sensitive to systemic chemicals. These are not good candidates. Large trees with significant top loss due to storm or heavy pruning may also suffer from chemical injury, but still are candidates for therapeutic treatment.

2. Treatment timing. Elms with advanced symptoms, e.g., more than 5% infection, especially those showing symptoms before June 15, may not respond favorably. The latter are carryover infections from the previous year, and the fungus is often too well established in such trees. Consequently, trees that first show symptoms after July 1 are the best candidates for therapeutic treatment. Treatment should be made as soon after symptoms appear as possible.

Trees may be injected preventively anytime during the growing season after leaves gain full size, and when there is sufficient moisture in the ground to encourage good uptake and distribution of the chemical. May and June are probably best.

3. Chemicals available. Two chemicals on the market are currently being used to treat Dutch elm disease. Arbotect 20-S has been successfully used to treat many elms. Alamo is a newer product that has also given good results.

4. Supplemental pruning.

Removing diseased branches, well below the point where internal symptoms can be observed, may improve therapeutic treatment. In rare cases, pruning has reportedly saved elms without chemical injection.

Resistant elm cultivars

Several elm cultivars with resistance to Dutch elm disease have been introduced as a result of University of Wisconsin research programs. The first cultivar was 'Sapporo Autumn Gold,' followed by 'Regal,' 'New Horizon,' and 'Cathedral.'

Each of these cultivars has their own character which is not entirely like the American elm. 'Sapporo Autumn Gold' is similar to the Japanese elm with more branching and smaller leaves than the American elm. 'Regal' has a columnar form. 'New Horizon' is a slower growing and more compact elm. They all have adequate resistance to Dutch elm disease. For information on purchasing these cultivars, contact the McKay Nursery Company, Waterloo, WI 53594.

The 'American Liberty' elm, actually a group of closely related clones, represents the most Dutch elm disease resistant selections available from the American elm. It has adequate disease tolerance when used sparingly and not closely planted to prevent possible disease spread via root grafts. 'American Liberty' elms are available through the Elm Research Institute, Harrisville, NH 03450.

Work is ongoing both in Wisconsin and nationally to develop more elm varieties with resistance to Dutch elm diseases.

Better care of all trees, not just elms, is also important. Greater appreciation of the role of municipal and commercial arborists and training programs that continue to increase their competency are essential. Private tree owners should learn the fundamental requirements of tree care, since many valuable trees are lost to homeowners each year through improper care or treatment.

Municipalities should encourage tree planting programs that include a wide range of species. Mixed tree populations that are not dominated by any single species are much less subject to disease or insect epidemics. Proper tree selection, site selection and spacing can reduce problems for future generations and insure that we will have the benefit of trees.

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