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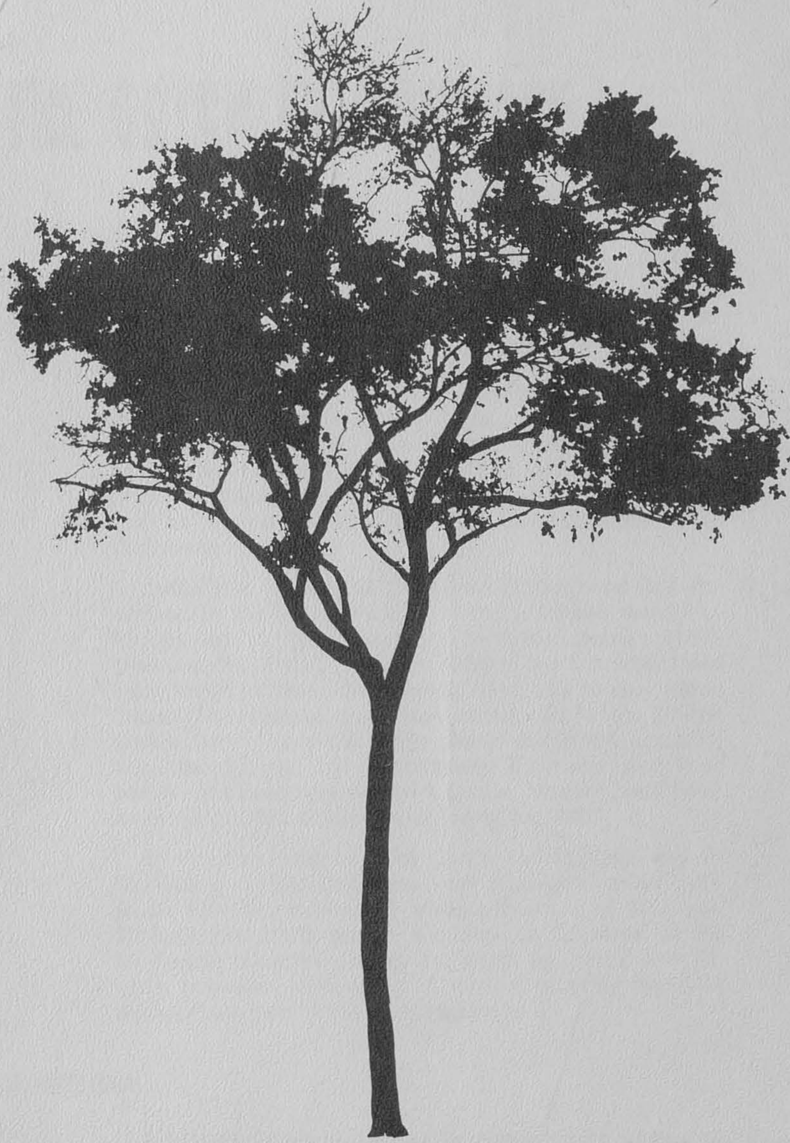

THE DUTCH ELM DISEASE

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Cover illustration: Dutch elm disease appears
as the dead portion of the tree

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THE DUTCH ELM DISEASE

All species of elms native to North America are susceptible to Dutch elm disease. The most common elm species is the American elm, *Ulmus americana*, occurring naturally over most of the eastern United States from southern Canada to central Florida and west to the Rocky Mountains. It has been extensively planted and will grow in a wide variety of soils and tolerates a wide range of soil moisture. Some of the European selections are more resistant than the American elm. Siberian elm, *Ulmus pumila*, which has been planted in shelter belts and as a shade tree, is resistant, but not immune to Dutch elm disease.

Dutch elm disease, as the name implies, was first described in the Netherlands in 1919. It spread rapidly in Europe and by 1934 was found in most European countries and the British Isles. In 1930 a few diseased trees were found in Ohio. *Ceratocystis ulmi*, the fungus which causes this disease, had been introduced to the United States from Europe in logs which contained probably both the fungus and the smaller European elm bark beetle. The European elm bark beetle, however, had been reported in Massachusetts as early as 1909.

Minnesota's first case of Dutch elm disease was in St. Paul in 1961. The same year 7 infected trees were found near Monticello, 40 miles northwest of St. Paul. Through the 1973 season the disease appeared in 61 Minnesota counties and as far north as Itasca and St. Louis counties. However, it is most frequently found in the southern part of the state (figure 1).

SYMPTOMS

Dutch elm disease results in rather rapid wilting of foliage. Some trees die a few weeks after becoming infected. Other trees wilt slowly and survive for a year or longer. Usually the first evidence of the disease is wilting or flagging in one or more of the upper branches. Leaves on affected branches turn dull green to yellow and curl. When the infection becomes systemic (involves large sections of the tree) the tree will wilt rapidly.

A brown, discontinuous ring forms in the outer sapwood of wilting branches, usually in the springwood

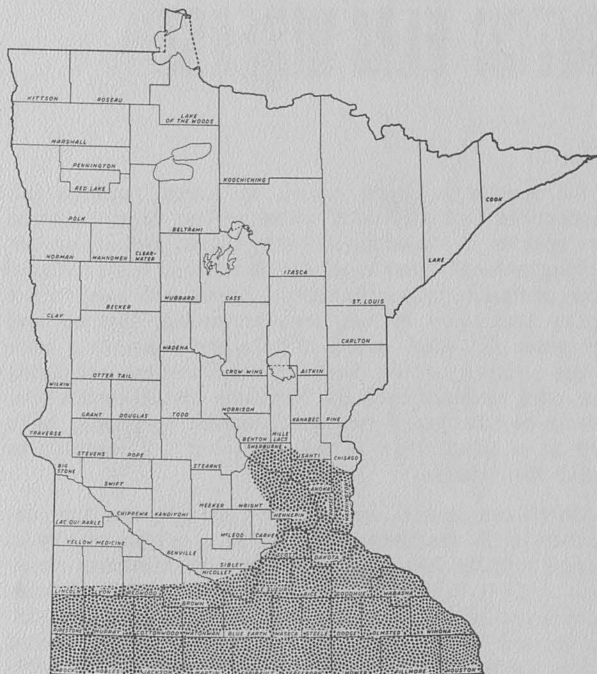

Figure 1. Shaded areas indicate high incidence of Dutch elm disease.

vessels (large diametered vessels formed early in spring) of the current year's growth. Peeling bark from wilted branches reveals light to dark brown streaks or solid discoloration of the wood beneath the bark (figure 2). Although other fungus diseases and wounds can cause similar discoloration, these discoloration and wilting symptoms are sufficient evidence of Dutch elm disease in areas where the disease is common. Control measures should be initiated without waiting for laboratory confirmation.

Positive identification of the disease, however, requires laboratory confirmation. In areas where Dutch elm disease is not common, laboratory culture of the fungus is suggested. Samples should be about ½ inch in diameter, 5-10 inches long, and should be from a branch which is wilting (the fungus cannot be isolated from dead, dried branches). Samples may be sent to:

Dutch Elm Disease Laboratory
670 State Office Building
Division of Plant Industry
St. Paul, MN 55155

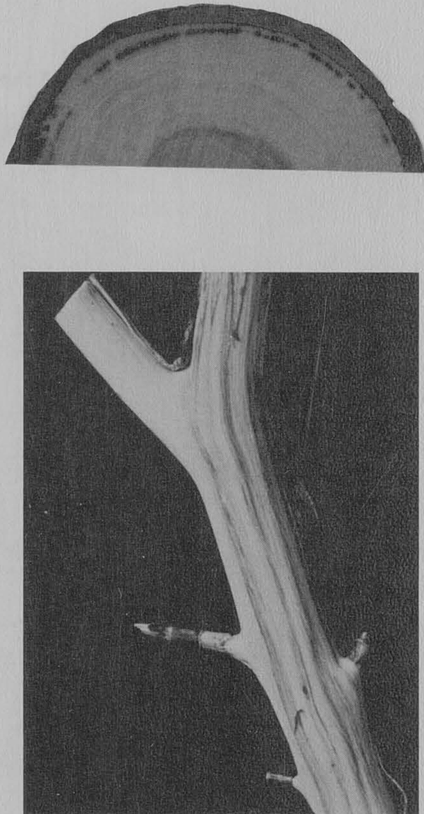

Figure 2. This cross section and stripped branch show the discoloration beneath the bark which can mean Dutch elm disease.

CAUSE — LIFE HISTORY

The fungus *Ceratocystis ulmi* invades and grows in the water-conducting vessels of the elms, inducing the host tree to produce tyloses and gums which together with the fungus plug the trees' vessels, preventing the uptake of water. This causes the tree to wilt and die.

In the U.S. the fungus is spread by the smaller European elm bark beetle, *Scolytus multistriatus*, and the native elm bark beetle, *Hylurgopinus rufipes*. The European species overwinters in the larval stage under the bark of dead elm trees or logs. The larvae pupate and adult beetles emerge in May: in cool weather, this could be later. The native beetles winter both as adults and larvae. The eggs are laid in both the fall and the spring (figure 3).

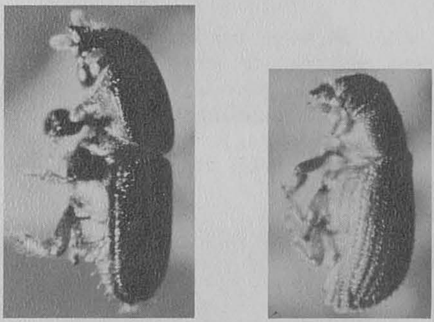

Figure 3. European elm bark beetle (left) and the native elm bark beetle (right). Both adults are about 1/8 inch long.

In trees infected with Dutch elm disease, the fungus produces spores in the larval tunnels. The adult beetles which emerge from pupae at the ends of the larval tunnel are carrying spores both on the inside and outside of their bodies (figure 4).

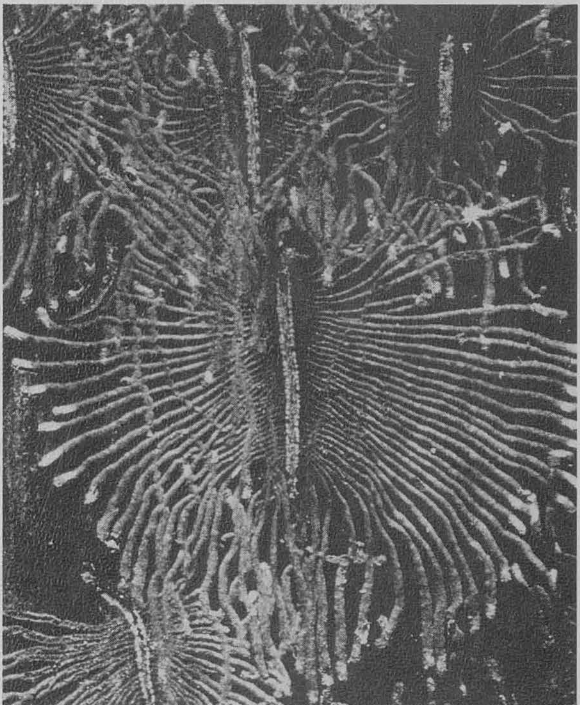

Figure 4. Eggs line up vertically under the bark and beetles emerge from pupae at the ends of the radiating larval tunnels.

The adult European beetles fly a short distance, about 100 feet, and feed on small branch axils. The native beetles feed on the bark of larger branches (4-10 inches in diameter) or on the main stem. It is during this feeding period that the fungus spores are introduced into the large springwood vessels of healthy trees (figure 5).

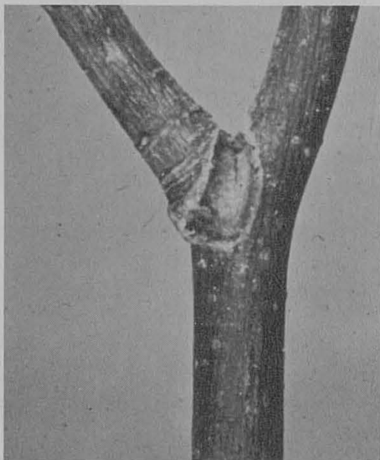

Figure 5. Smaller European beetles feed inside the crotch of this branch spreading the fungal spores of Dutch elm disease.

Once the fungus has entered the elm tree, it can move rapidly throughout the tree's vascular system resulting in systemic infection. More often, however, the initial spread of the fungus in the tree is relatively slow and on occasion may not become systemic. These early infections may not be very apparent, but when the fungus does move into the larger branches, rapid wilting occurs.

Feeding and tunneling activities by the adult beetles late in the summer apparently do not spread the disease. After feeding, the adult beetles search out suitable breeding sites under the bark of recently dead trees.

The fungus also can spread from tree to tree through root grafts (roots naturally fused together) especially if spacing is less than 30 feet between elms. Root grafting may occur between large trees up to 60 feet apart (figure 6).

It is very unlikely that the Dutch elm disease fungus can be spead on pruning equipment.

CONTROL

The primary emphasis in a Dutch elm disease control program is preventive action including the following:

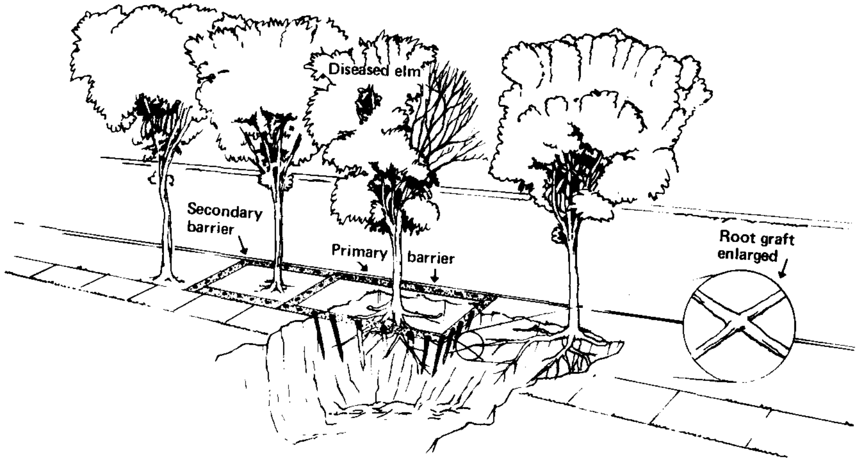

Figure 6. Root graft barriers stop underground spread of disease.

1. Sanitation — Destruction of dead and dying elms. This means destroying (burn, bury, chip, debark) trees with tight bark where elm bark beetle larvae can develop.
2. Disruption of root grafts between infected and healthy trees.

SANITATION

When about 90 percent of the dead elm trees and branches are eliminated each year, the disease is suppressed to minor proportions. Adults of the European elm bark beetle, in search of suitable breeding material, may fly for at least 3 miles. Trees infected as a result of beetle feeding usually occur within 100 to 200 feet of a diseased tree.

Sanitation measures must include the removal and destruction of all dying and dead elms, whether or not killed by Dutch elm disease (the fungus and beetles can be present in trees which did not die of Dutch elm disease). This eliminates all potential beetle breeding sites as well as diseased trees. When trees are felled, the aboveground stump should be removed or debarked.

Because many dead trees or dead portions of living trees may already contain beetles, trees should be destroyed before May 1 because beetles emerge in May and June. Although second generation beetles can emerge later in the summer they are unlikely to cause infection, as small diametered summerwood vessels are less susceptible to infection. It is advisable, however, to eliminate dying elms within 20 days of detection in the summer months (figure 7).

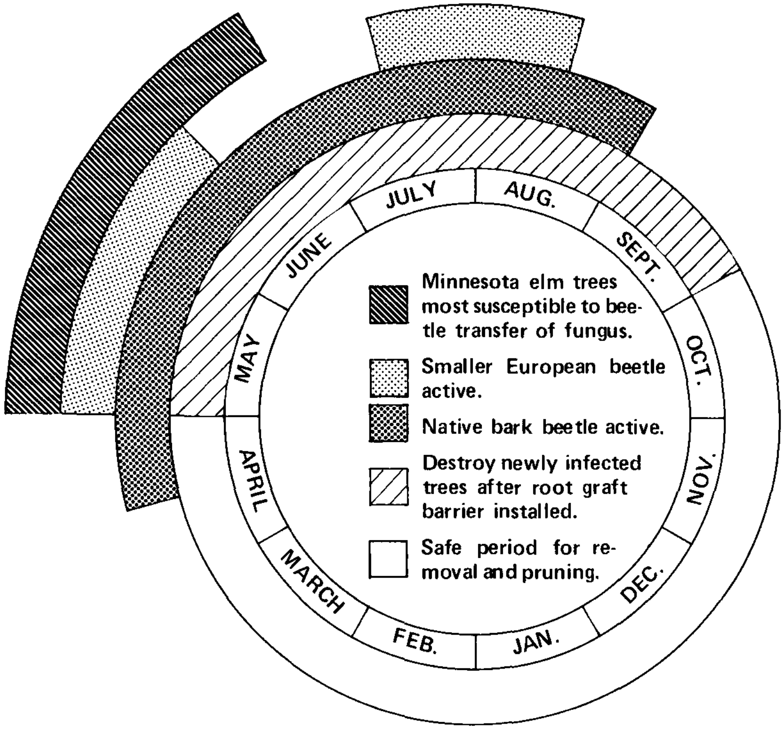

Figure 7. Dutch elm disease calendar.

There should be no movement of elm logs during May and June into or through areas where few cases of Dutch elm disease have occurred as beetles can emerge enroute and further spread the disease.

Chipping or sawing diseased wood into products is the best method of disposing of elm material. Chips are not susceptible to beetle invasion: larger products with the bark attached would be a hazard. If the elm logs cannot be used, they should be burned, buried, chipped, or debarked.

PREVENTION OF SPREAD THROUGH ROOT GRAFTS

The fungus causing Dutch elm disease commonly spreads from infected to nearby healthy trees through naturally grafted root systems. This spread can be prevented by mechanically trenching around infected trees, or by using a chemical, SMDC (Vapam or VPM). Since some apparently healthy trees may be infected at the time of treatment a trench is suggested between the trees closest to the diseased tree and the second closest trees (figure 8).

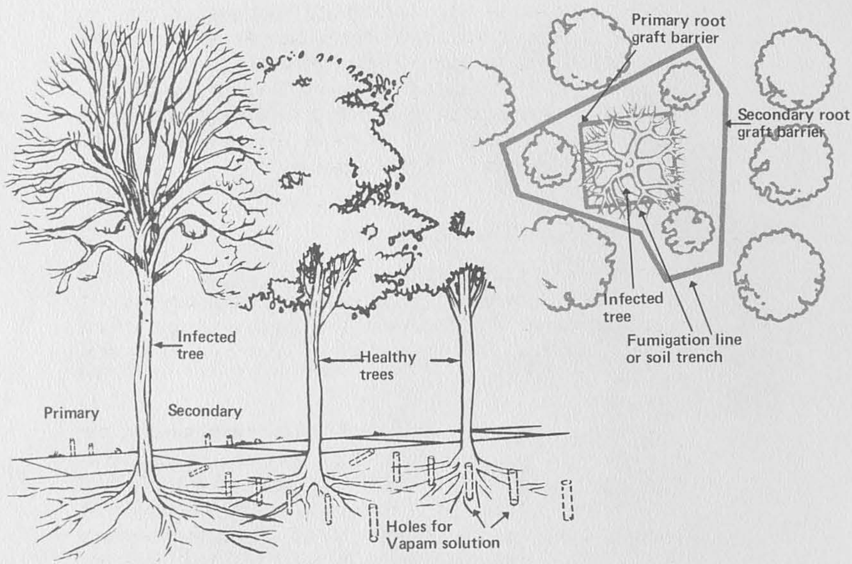

Figure 8. Typical root graft barrier installations.

A trench 36-40 inches deep between diseased and healthy trees immediately disrupts root grafts between these adjacent trees. A mechanical trenching machine is the easiest way to dig a trench but it must be used with care in rocky soils or where underground utilities are present. After the trench is completed, refill the trench, and remove the diseased elm trees immediately. To be doubly safe a second trench can be placed between the first healthy tree and the next healthy tree.

The chemical barrier is established on a line midway between the diseased tree and the adjacent healthy tree and should extend as far as necessary to disrupt all potential root grafts. A series of holes, 15-18 inches deep, about ¾-1 inch in diameter, and 6 inches-1 foot apart, are established along the Vapam barrier line. One part of SMDC is mixed with 3 parts of water and 50-200 milliliters (2-8 fluid ounces) of the diluted chemical are placed in each hole. The hole must be closed immediately after adding the SMDC. The SMDC should be applied 2 weeks before the tree is removed. SMDC should not be applied within 8-10 feet of a healthy tree. Some temporary injury may occur in a healthy tree because of root loss and chemical uptake. Soil temperatures below 50° F. and waterlogged soils reduce effectiveness of treatment.

Since the diseased tree and its root system die, regrowth of roots across the control barrier is not a problem. Root grafts can occur under sidewalks and driveways, therefore it is advisable to angle the fumigation hole underneath the asphalt or concrete to disrupt root grafts under these surfaces. All potential root grafts must be disrupted if spread is to be stopped

OTHER SECONDARY CONTROLS

Insecticides can be applied to healthy trees to prevent or reduce insect feeding; however, only methoxychlor is a possibility and it adds only a small additional protection. Without removal and destruction of infected trees, methoxychlor is ineffective.

Systemic fungicides that might save infected trees are much sought methods of control but are still doubtful. Benomyl (trade name Benlate) has received a great deal of publicity but has been of limited value. Benomyl has been cleared by the Environmental Protection Agency (EPA) for use on elm trees as a foliar or trunk injection treatment as an aid in the control of Dutch elm disease. It is to be used by trained arborists in conjunction with sanitation. The best application time is around June 1, as the tree reaches full leaf.

Trunk injection using benomyl at a rate of 2 pounds per 100 gallons of water in a pressure injection device at 20-30 pounds pressure per square inch also is EPA approved. Inject 1 gallon of suspension for each 10 inches of trunk diameter. Use at least one injection site for each 10 inches of trunk circumference. For smaller trees (less than 10 inches in circumference), use the amount of material injectable in ½ hour using two injection sites.

Pressure injection of trees, especially through several main roots, using a solubilized form of benomyl is more effective than cup applications, but EPA has not approved pressure injection. Also the solubilized form of benomyl is not now available.

Soil applications of benomyl are more promising than foliar or trunk injections but are unlikely to be EPA approved. Where foliar and stem applications are effective for a month or so, soil applications have been protective for more than the one year. Approximately 600 pounds per acre are required and the material should be injected into the soil.

Although various reports talk about curative as well as protective applications of benomyl, the only success of any consequence has been with protective treatments, applications before infection. Curative treatments, after infection, are very limited because of the problem in early detection, immediate treatment, and the need for rapid and complete distribution of the chemical. Root injection with solubilized benomyl is a technique which has had success as a curative treatment but is not EPA approved.

EXTENSIVE TREE SURGERY

Some evidence indicates that if early infections are removed an elm can be saved by radical pruning. A minimum of 10 feet of streak-free wood (no vascular discolorations) needs to be removed below obviously infected branches. Elms should not be pruned in August and early September because wounds attract beetles which may introduce the fungus.

DETECTION

An essential part of any control program is the detection of infected trees. In this surveying process, it is desirable to determine total tree populations. The three survey methods, each with its advantages and disadvantages, follow:

1. Ground survey.
2. Aerial survey with direct observation from a helicopter or fixed-wing aircraft.
3. Aerial photography.

Ground Survey

Ground survey crews, able to work in most weather conditions, will detect a high percentage of the diseased trees. Diseased trees are marked for removal or sampled all in the same operation.

Ground surveys are slow and in wild or undeveloped areas their efficiency is reduced. Early infections evident only in the tops of trees can be missed from below. Ground surveys cost more than other methods.

Aerial Survey

Results of direct observation from aircraft have been disappointing because only about 50 percent of the diseased trees are detected.

Advantages of this technique are the speed and low cost of the operation. Disadvantages are the lack of accuracy, weather limitations on flying time, problems in mapping locations of diseased trees, and dependence on ground crews to mark or sample diseased trees. Helicopter surveillance serves well as a followup to other methods to insure that all diseased trees have been removed.

Aerial Photography

While aerial photography lacks the accuracy of a ground survey, it does provide an accurate up-to-date map of diseased trees and information on total tree populations. Aerial photography can be accomplished very quickly, providing weather is suitable and aircraft available. Contracts for aerial photography need to be handled by a specialist to insure adequate coverage with proper film, filter, and scale. To date, it appears that Ektachrome infrared film with a Wratten 12 or 21 filter at a scale of 1:9600 is best. Various cameras are available for aerial photography and although 9 inch film is excellent, 70 mm or even 35 mm has possibilities.

The cost of aerial surveys vary, but would be about half that of ground surveys. Aerial photography will be of most value to the community if flown in early July when trees are wilting and color contrasts are maximum. A second survey, if flown, should be completed before August 15 to avoid fall coloration and discolorations of foliage caused by other factors.

Prospect for Control in Minnesota

Excessively cold winters and highly fluctuating temperatures in spring may make Dutch elm disease control programs more successful in Minnesota than in areas south and east of Minnesota. However, an effective control program as described is necessary to keep elm losses at low levels in Minnesota.

RESISTANT ELMS

All species of elm are more or less susceptible to Dutch elm disease. Individual trees, especially in the Chinese and Siberian elm group, have some resistance. These trees may serve as replacements for more susceptible elms; however, many of them are not winter-hardy in Minnesota. So the alternative is to plant other kinds of trees.

Other tree species are subject to other problems. Therefore, it is better to plant mixtures of trees rather than to rely on one species.

RECOMMENDED SHADE TREES

The following trees can be planted in place of elm or in mixed plantings with elm:

SUGAR MAPLE — Reasonably free of insect and disease pests, but requires better soil. It is subject to Verticillium wilt, which results in dieback or death of the tree. However, this is not as serious a disease problem as Dutch elm disease.

NORWAY MAPLE and its varieties — Reasonably free of insect and disease pests, but is subject to Verticillium wilt.

SILVER MAPLE — Fast-growing species subject to tar spot and mites that are of no serious consequence. It also is subject to decay.

GREEN ASH and its varieties — Free of serious pests. But in some parts of the country, including Minnesota, some ash are dying from an unknown cause. In some years, ash plant bugs and aphids have caused minor damage to this species.

BASSWOOD — Reasonably free of insect and disease pests. It is more subject to decay than many other species.

HACKBERRY — Slow growing and subject to witches'-broom and gall forming psyllids. Neither of these pests causes serious tree damage. By selecting the right strain of hackberry, witches'-broom might be avoided.

RED OAK — Reasonably free of insect and disease pests except for oak wilt, which is not likely to be a problem in boulevard plantings.

FLOWERING CRABAPPLES — Small colorful trees subject to fire blight, cedarapple rust, and other diseases and insects.

RED MAPLE — Has no major pests and when available is an excellent tree (this is not a variety of Norway maple, which has red foliage during the summer).

IRONWOOD — A small tree, free of serious pests.

HONEY LOCUST — (especially thornless varieties). Subject to a canker disease, but otherwise reasonably pest free.

For additional information on deciduous trees, see Extension Bulletin 267, "Woody Plants for Minnesota." In northern Minnesota, such conifers as red pine and white pine may be excellent substitutes for elm (see Extension Bulletin 258, "Evergreens").

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