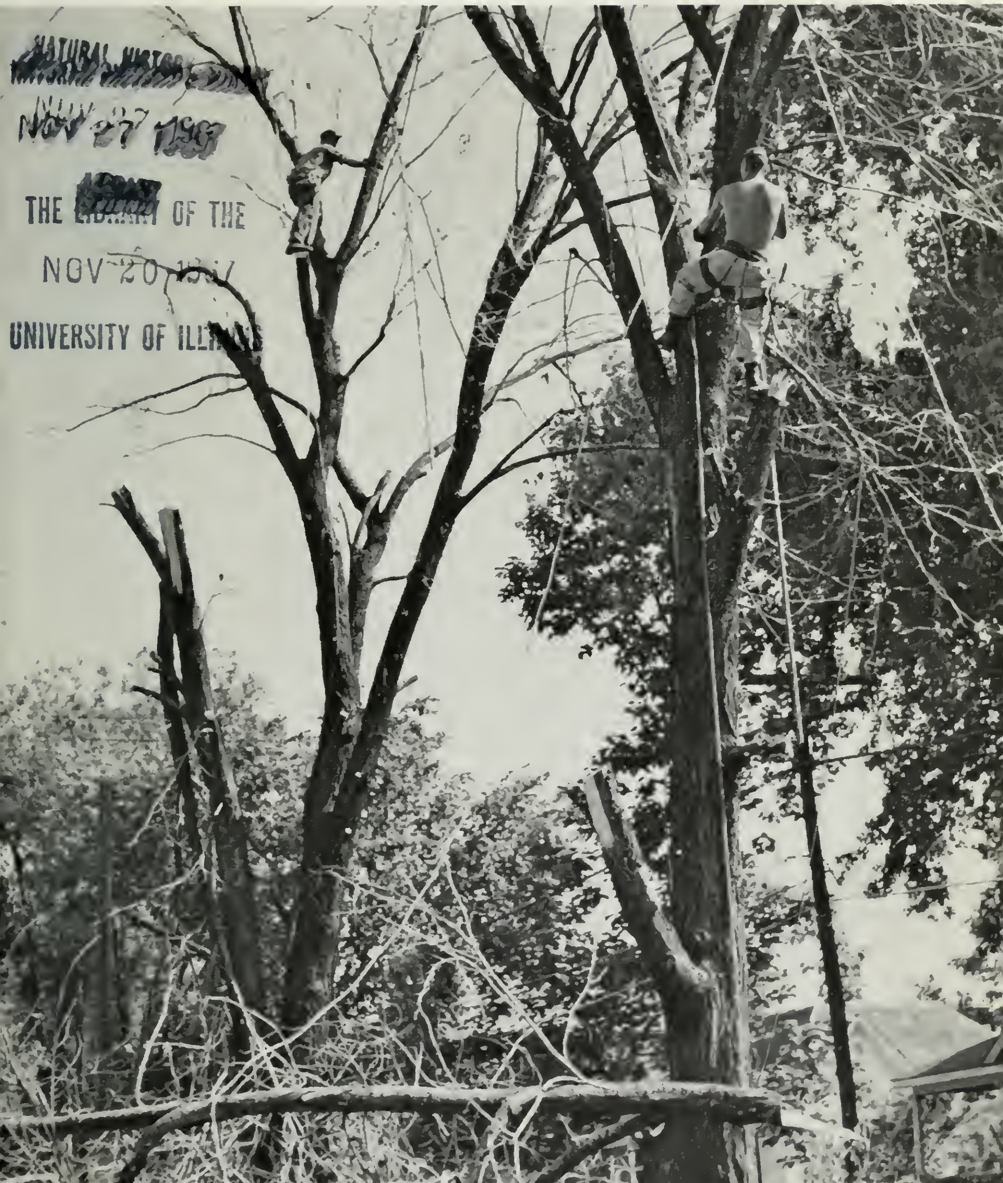
Dutch Elm Disease in Illinois

J. Cedric Carter

Circular 53



ILLINOIS NATURAL HISTORY SURVEY

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The stately American elms that formed a cathedral-like arch over the University of Illinois broadwalk in Urbana (above) are gone. The area has been replanted (below) with other species of deciduous trees.

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DUTCH ELM DISEASE has killed millions of elm trees since its introduction into the United States. It was discovered at Cleveland and Cincinnati, Ohio in 1930, and in Connecticut, Maryland, New Jersey, and New York in 1933. Although the disease appeared at Indianapolis, Indiana in 1934, it was not found in Illinois and Michigan until 1950. Since 1950 the disease has spread rapidly throughout the midwestern states and by 1966 was present in 30 states, the District of Columbia, and three provinces of Canada. It occurs from the Atlantic Coast west to Nebraska and Colorado and from Georgia, Arkansas, and Oklahoma north to the Canadian provinces of Ontario, Quebec, and New Brunswick. By 1959 the disease was found in every county in Illinois.

Some Illinois cities lost nearly all of their elms to Dutch elm disease in a period of 10–12 years. After a rapid buildup of the disease during an initial period of 5–7 years, losses have ranged from 15 to 20 percent of the existing elm population each year. These losses have continued until about 95 percent of the elms once present have been killed. This rate of dying means that, in a city that once had an elm population of 20,000 trees, 19,000 have been killed.

The cost of removing 19,000 elms at $75 per tree is $1,425,000, and removal cost of $75 per tree is less than the average paid by many cities. A control program that holds the annual loss of elms to 2 percent or less of the current elm population is desirable because it avoids exorbitant tree removal costs, prevents devaluation of real estate, and ensures the continued enjoyment of elms as shade trees.

SYMPTOMS AND CAUSE

The first noticeable symptoms of Dutch elm disease are wilting, curling, and yellowing of leaves on one or more branches, a condition often called "flagging." These symptoms are followed by dying and browning or premature falling of leaves, and death of affected branches. Some affected trees first show wilting of leaves on one or a few branches (Fig. 1), followed by wilting of leaves on additional branches and finally death of the affected trees. Elms affected in this manner in early summer may die during the same growing season. Those affected in late summer may die during the winter, soon after leaves appear in the spring, or slowly over a period of a year or more. Other elms may show foliage wilt on most or all of their branches at one time and die within a few weeks (Fig. 2). Trees that

Fig. 1.—The earliest visible symptoms of Dutch elm disease are the wilting, curling, and yellowing of leaves on one or a few branches. On this tree the wilted and curled leaves are evident on the branch at the left.

wilt and die rapidly probably became infected during the previous growing season, at which time they would have shown no wilt symptoms or only limited and relatively inconspicuous symptoms.

Brown streaking develops in the sapwood of diseased branches. It appears mostly in the springwood of the current-season growth. In a cross-section of a branch, browning may appear as a series of dots in a single wood ring (Fig. 3) or the dots may be so abundant that the entire wood ring appears brown. In branches on which leaves wilt before summerwood is produced, the discoloration is usually conspicuous as fine streaks on the surface of the wood when the bark is carefully peeled from the diseased branch (Fig. 4). The outer surface of sapwood on trunks may also be brown (Fig. 5).

The presence of brown discoloration in young sapwood is used in the field as a diagnostic symptom of Dutch elm disease. Although several wilt diseases of elm cause similar browning of young sapwood, trees showing this discoloration in areas where Dutch elm disease occurs are most likely affected with Dutch elm disease. However, if the presence of the fungus in the tree must be determined, it is necessary to make laboratory tests of specimens from the diseased tree. With these tests the organism involved is isolated and the specific disease present is determined. However, in some instances the fungus is not obtained by a culture test even though the tree is affected by the disease.

Dutch elm disease is caused by the fungus *Ceratocystis ulmi* (Buisman) C. Moreau. In living trees this fungus grows in the sapwood, most frequently that of the current season, and causes the

Fig. 2.—Some affected elms, such as this one, show foliage wilt on most or all of their branches at one time and die rapidly.

Fig. 3.—In cross-section, the brown streaking caused by Dutch elm disease may appear as a series of dots, as shown here, or as a solid brown band in a single wood ring.

brown discoloration (Fig. 3, 4, and 5) described above. In dying and dead trees invaded by bark beetles, the fungus grows in the galleries made by the larvae or grubs of the beetles (Fig. 6). These galleries are in the inner layers of bark with groovings on the outer surface of the sapwood.

Fig. 4.—The removal of bark from branches that wilt in early summer usually reveals long, broken, brown streaks on the surface of the sapwood.

Fig. 5.—Brown discoloration of the outer surface of sapwood on the trunks of wilting elms is a common symptom of Dutch elm disease.

Fig. 6.—Galleries in which the smaller European elm bark beetles lay eggs are parallel to the grain of the bark and wood; they are few and relatively large. Galleries made by the larvae or grubs of this bark beetle are perpendicular to the grain of bark and wood; they are numerous and relatively small. When the bark is removed, the white larvae are conspicuous at the tips of many of these galleries.

HOW THE DISEASE SPREADS

The Dutch elm disease fungus is transmitted to healthy elms in two ways: (1) by insects, (2) through roots that become grafted together between diseased and healthy trees.

Insect Carriers

The insects that transmit the Dutch elm disease fungus in the United States are the smaller European elm bark beetle, *Scolytus multistriatus* (Marsham), and the native elm bark beetle, *Hylurgopinus rufipes* (Eichhoff).

The smaller European elm bark beetle (Fig. 7), principal carrier of the fungus, feeds mainly in crotches of 1- and 2-year-old twigs (Fig. 8). The fungus spores (Fig. 9), deposited in the feeding wounds (Fig. 10), grow and spread in the vessels of the young sapwood. Infection occurs mainly in May and early June, when the springwood vessels are adjacent to or near the inner surface of the bark. In time the leaves on branches invaded by the fungus wilt and the branches die.

In Illinois there are two broods of the smaller European elm bark beetle each year. The first brood of adult beetles (which have overwintered as larvae in elm bark) starts emerging in May and continues to emerge until mid-July. Emerging beetles make small holes in the bark (Fig. 11). Peak emergence of this brood occurs in mid-June. The second brood, which develops in 5–7 weeks from eggs laid

Fig. 7.—Adult of the smaller European elm bark beetle. It is shiny, dark reddish brown, and about one-eighth inch long.

Fig. 8.—Close-up of a bark beetle feeding in the crotch of a young shoot. Spores of the Dutch elm disease fungus adhere to the body of this beetle.

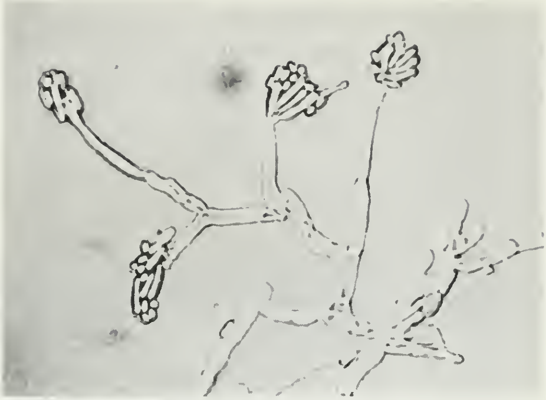

Fig. 9.—Magnified view of fungus that causes Dutch elm disease. These colorless, oval spores, produced on short fungus strands, are not visible to the naked eye.

Fig. 10.—The Dutch elm disease fungus is introduced into healthy elms through bark beetle feeding wounds made in the crotches of 1- and 2-year-old shoots. These wounds extend to the sapwood beneath the bark.

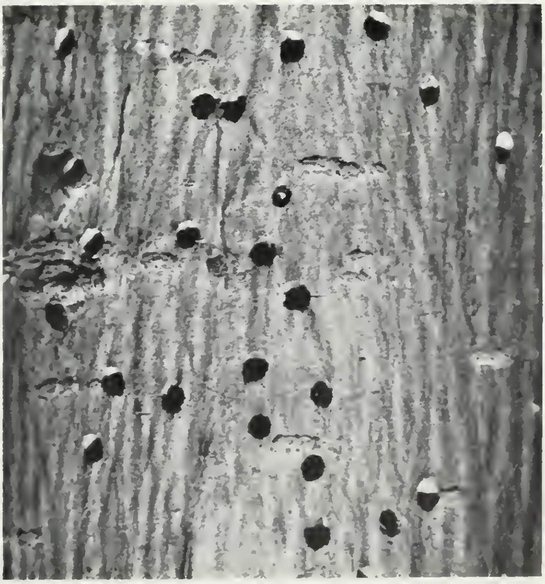

Fig. 11.—The smaller European elm bark beetles make numerous small holes in the bark as they emerge. The holes resemble those made by small buckshot.

by the first brood, starts emerging in mid-July and continues to emerge until late September. Peak emergence occurs in mid-August. Eggs laid by this second brood develop into larvae (Fig. 6 and 12) which overwinter in the bark. These larvae burrow into the inner bark of infested elm material, where they are well protected during the dormant season. The fungus persists from one year to another in the infested material.

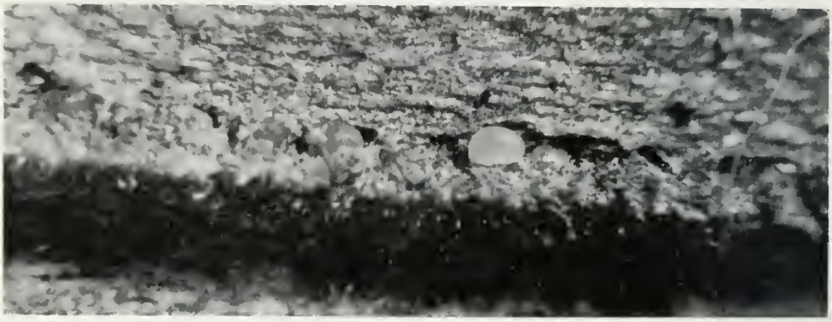

Fig. 12.—This enlarged section of an egg gallery shows young larvae or grubs along the edges.

Root Graft Transmission

The fungus spreads through grafted roots between diseased and healthy trees. Natural grafting of roots occurs between elms growing near one another (within 35 feet in the case of large trees). The amount of annual infection through grafted roots varies in different communities depending on the spacing of the elms.

SUSCEPTIBILITY OF DIFFERENT SPECIES

No species or variety of elm is known to be immune to Dutch elm disease. Trees in the related genera of *Planera* and *Zelkova* have become diseased when inoculated with the Dutch elm disease fungus. It is unfortunate that the American elm, a longtime favorite for both shade and ornamental use, is the most susceptible of all elms. Although Chinese and Siberian elms are highly resistant to the disease, trees of these species have succumbed to natural infection in Illinois.

Several hybrid elms reported as crosses between Asiatic and American species have been advertised as immune or resistant to Dutch elm disease. The hybrid elms of this type which were tested by Natural History Survey scientists were not immune, although they did show resistance somewhat comparable to that of the Siberian elm. Other resistant elms include the Christine Buisman and Bea Schwarz seedling selections of the smooth-leaved elm.

Variations in resistance to Dutch elm disease are indicated to some extent by the number of elms that have survived on the University of Illinois campus in Urbana. The first recorded instance of Dutch elm disease on the campus was an infected American elm observed in June 1951. From then to 1967 the disease killed 1,606 of 2,196 American elms (559 were killed by phloem necrosis, a virus disease), 1 of 52 Chinese elms, 12 of 14 slippery elms, 1 of 3 Holland elms, and both of 2 rock elms.

Other elms on the campus (in limited numbers), none of which have been killed by Dutch elm disease, are Camperdown, globe, Huntingdon, Jersey, Siberian, smooth-leaved, and Wych elms.

DISEASE CONTROL PRACTICES

Although no treatment is known that will cure Dutch elm disease, annual losses caused by the disease can be maintained at a very low level by a program of sanitation, spraying with an insecticide, and treating grafted roots with a soil sterilant when elms are growing close enough together so that root grafts occur.

Sanitation

Sanitation is a basic procedure for a successful control program, so important that spraying without sanitation is not recommended. Beetle-infested elm material found between May 1 and August 1 should be disposed of immediately or sprayed with DDT. A spray of DDT, 1 percent, in No. 2 fuel oil will prevent fungus-infested beetles from escaping and carrying the fungus to healthy trees. (This spray is inflammable until thoroughly dry, and it will kill vegetation.) Beetle-infested material found after September 1 should be disposed of by May 1 of the following year.

A sanitation program is likely to fail if it is based on the destruction of only those elms that are shown by laboratory culturing to be infected by the Dutch elm disease fungus. Bark beetles lay eggs and produce offspring in elms that are weakened or dying, or that have been recently killed by disease, drought, lightning, excavation, or other mishaps. They may also lay eggs and produce offspring in elm stumps and in elm logs in woodpiles. Bark beetles infested with spores of the Dutch elm disease fungus will carry the spores into the galleries in which they lay eggs. The fungus will grow throughout the galleries and the young bark beetles that later emerge from this infested wood will carry the fungus to any trees upon which they feed. Therefore, effective sanitation is the careful, thorough, and prompt removal (cover photo) and proper disposal of all elm trees and other material in which bark beetles can colonize. This material includes weakened, dying, and recently killed elms, all elm woodpiles (Fig. 13), bark on stumps (Fig. 14), and weakened or dying branches on healthy trees. Proper disposal of elm material consists of burning it before the beetles can emerge.

Fig. 13.—Elm branches and trunks with bark intact and stored in piles are excellent for colonization by bark beetles. For effective sanitation, such material must be destroyed before the beetles can emerge.

Fig. 14.—Elm stubs and stumps left standing are suitable for bark beetle colonization. For effective sanitation, they must be burned, or the bark must be removed, before the beetles emerge.

Spraying

Spraying with special formulations of methoxychlor or DDT will help to protect healthy elms from fungus infection by preventing bark beetle feeding.

The heavy applications of these insecticides required for bark beetle control are hazardous to birds and other warm-blooded animals. Methoxychlor, although more expensive, is less hazardous than DDT. To minimize the hazard it is recommended that methoxychlor be applied as the spring dormant spray and that DDT be applied as the fall dormant spray. Methoxychlor, as a fall dormant spray is *not* effective for a period of time sufficient to control elm bark beetles throughout the following spring and summer. According to available data it was effective for only 100 days in tests conducted by the University of Wisconsin and 150 days in USDA tests in Washington, D.C. Some municipalities in Illinois now use methoxychlor as a spring dormant spray.

Properly formulated concentrates of these insecticides are available commercially. Although they will not give complete protection of all sprayed trees, when combined with sanitation and the prevention of fungus transmission through grafted roots they give the best protection against Dutch elm disease known at present. These insecticide treatments reduce the chance of infection by killing many of the fungus-bearing beetles before they can gnaw through the bark and deposit fungus spores in the sapwood of healthy trees.

A single dormant spray is recommended for elms sprayed on a communitywide basis. It may be applied in fall or spring, at any suitable time after the leaves have fallen—in late October or November, or until new flowers or leaves appear, in April or early May. This spray should contain 12 percent insecticide if it is applied with a mist blower or 2 percent insecticide if applied with a hydraulic sprayer.

To effectively prevent bark beetle feeding, all bark surfaces must be completely coated with insecticide. Special care is required to thoroughly coat the crotches of young shoots, especially those in the upper parts of trees. The time to spray trees is when the wind velocity is less than 5 miles per hour, when the bark is dry, when rain is not anticipated for 2 hours after spraying, and when the temperature is above freezing.

Recently, helicopters have been used for spraying in some municipalities. At present, there is not sufficient data to show that helicopters are as effective as conventional sprayers in applying insecticides for Dutch elm disease control.

Caution: Like most other insecticides, these materials are poisons and must be handled with care and as directed by the manufacturers. The amount of spray applied should be kept to an effective minimum—for an average 50-foot elm, 2–3 gallons of spray if a mist blower is used and 20–30 gallons if a hydraulic sprayer is used.

Watering places, feeding stations, and other places frequented by birds, as well as fish ponds, should be protected from spray drift and runoff. It is recommended that bird baths be cleaned following spraying, and that the collection of spray in puddles, likely to occur where hydraulic sprayers are used, be eliminated. In spite of these precautions, it is probable that some birds will be killed, especially robins early in the season.

Killing Grafted Roots

Wherever elms are close enough together (up to 35 feet apart) so that root grafts occur, the Dutch elm disease fungus can pass from diseased to healthy trees. This spread of the fungus can be prevented by killing segments of roots with SMDC (32.7 percent sodium methyldithiocarbamate), available commercially as Vapam or VPM. For most effective results the chemical must be applied as soon as a diseased tree shows earliest wilt symptoms.

Treating with SMDC consists of placing the diluted chemical (1 part chemical and 3 parts water) in ¾-inch holes in the soil, 15 inches deep and 6 inches apart, in a straight line equidistant between trees (Fig. 15). The holes can be made with a ¾-inch auger bit or other suitable equipment. For effective control, the line of holes must be long enough to include all grafted roots, usually 15 or more feet. However, the line of holes should be at least 10 feet from the trunk of the healthy tree. About ½ cup of the liquid is placed in each hole. It is suggested that the chemical be poured into the holes slowly and carefully, to keep turf injury to a minimum. As soon as the chemical is dispensed the hole is closed by tamping to prevent loss of vapors.

When obstructions such as pavement or plant material prevent application of the chemical in a straight line, the pattern of holes can be varied to fit the circumstance, as illustrated in Fig. 15.

The diseased tree should not be removed for 2 weeks after treating. This will allow adequate time for the sap to stop flowing through the poisoned root sections. Upon removal, the tree must be burned as described under "Sanitation."

Treating with SMDC causes very little disturbance of turf since the circle of grass killed around the holes is only 3–6 inches in diameter. These dead areas can be reseeded or resodded 4–6 weeks after the chemical is applied. Also, this method of treating is easy and inexpensive, and does not damage underground cables, pipes, and other objects.

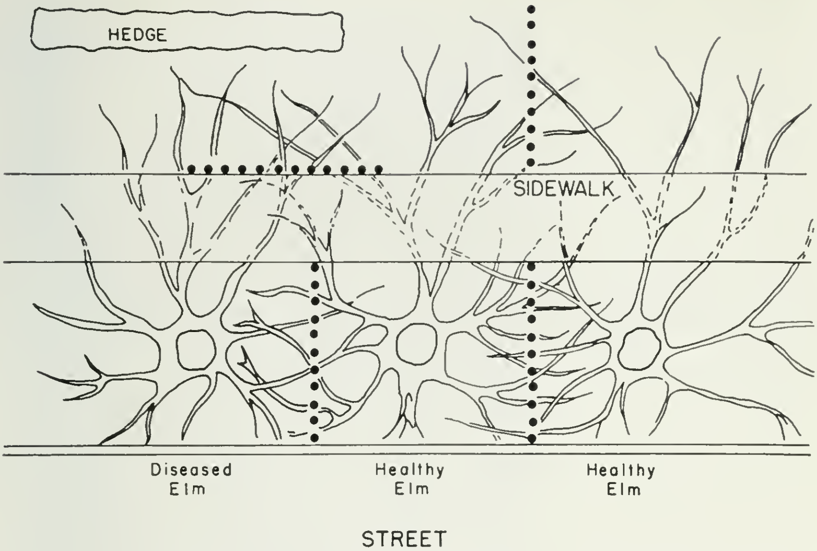

Fig. 15.—The rows of black dots show two patterns of applying a soil sterilant to prevent spread of the Dutch elm disease fungus. The "T" pattern is used to avoid injuring the nearby hedge. When the diseased tree shows advanced wilt symptoms, it is advisable to establish a second barrier between the healthy trees.

Additional Control Treatments

Potassium iodide. This treatment is sometimes used as a supplement to sanitation. In woodlands and other areas where it is not feasible to burn trees, or in municipal areas where elms cannot be removed promptly, bark beetles can be prevented from colonizing in diseased trees by impregnating the outer sapwood and bark with potassium iodide. Elms are killed by this treatment (Fig. 16). For most effective distribution of this chemical, diseased elms must be treated when earliest symptoms of foliage wilt are visible.

The potassium iodide solution (4 pounds of the chemical per gallon of water) is applied to each tree in an ax frill. The ax frill is made by chopping a continuous angling cut around the trunk (Fig. 17), cutting through the bark and at least three wood rings. The potassium iodide solution, approximately 1 pint per tree, is slowly poured into the frill as the operator circles the tree two or three times. This procedure allows time for the chemical to penetrate the sapwood.

In woodland areas where elms are of little value, or in other areas where sanitation and spraying are not carried out, potassium iodide can be used to advantage to poison all healthy elms before they become diseased and colonized by bark beetles.

Fig. 16.—Elms killed with potassium iodide, as shown by the tree at left which has lost its bark, will not be colonized by bark beetles.

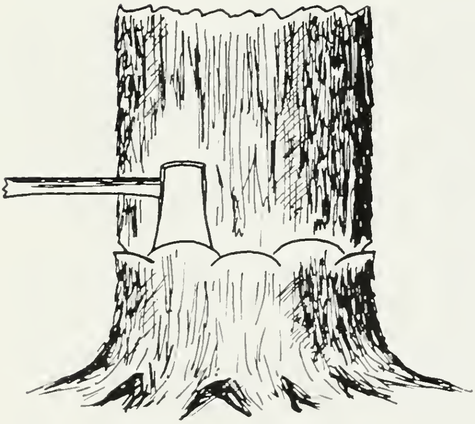

Fig. 17.—An ax frill, in which potassium iodide is introduced into a tree, is made by chopping a continuous angling cut around the trunk.

Foliar spray. To obtain maximum protection of special value elms, a foliar spray can be applied after second growth of leaves occurs, usually in late July in Illinois. This foliar spray is half the strength of the dormant spray described in the "Spraying" section. It is not recommended for a communitywide control program.

Pruning. Pruning infected branches will eliminate the Dutch elm disease fungus if it is confined to the portion of the branch removed. However, by the time most elms show wilt symptoms the fungus most likely has spread into the larger branches or the trunk. When this has occurred the fungus will not be eliminated by pruning. Also, pruning gives no protection to the rest of the tree. Pruning for Dutch elm disease control is not recommended as a general procedure.

Internal medication or chemotherapy. Research on the introduction of chemical compounds into elms for protection against Dutch elm disease began about 1940, and since then thousands of compounds have been tested. The types of materials tested include insecticides, fungicides, antibiotics, repellents, and growth regulators. In much of the early research inorganic compounds were tested. In the more recent research mainly organic compounds with systemic properties (capable of killing the fungus or insects when carried in the sap) have been tested. Although some of these materials have shown promise of protecting healthy elms against the disease, more research is needed before any of them can be recommended.

One chemical compound currently publicized for the control of Dutch elm disease is the systemic insecticide Bidrin. Experimental testing of this compound for Dutch elm disease control started in 1958. The results obtained by the various states and the U.S. Department of Agriculture Forest Service are not in agreement. In 1965, the results reported by some research workers indicated effective control while the results reported by others indicated none. After careful consideration of the available data from the federal government and the various states, the Natural History Survey does not recommend the use of Bidrin for the control of Dutch elm disease.

THE DUTCH ELM DISEASE LESSON

Because trees are living plants, subject to many hazards which will impair their value or cause them to die, a tree care and replacement program is necessary to maintain the trees needed for shade and ornamental purposes.

The spectacular loss of elms from Dutch elm disease emphasizes the importance of planting a variety of trees to avoid similar catastrophes in the future. It is suggested that any one kind of tree should not represent more than 10 percent of the total tree population of a planted area. Many species and varieties of trees are available for shade and ornamental purposes. Information on trees suitable for these purposes is given in Natural History Survey Circular 51, "Illinois Trees: Selection, Planting, and Care."

Some Publications of the ILLINOIS NATURAL HISTORY SURVEY

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Volume 27, Article 5.—Hook-and-Line Catch in Fertilized and Unfertilized Ponds. By Donald F. Hansen, George W. Bennett, Robert J. Webb, and John M. Lewis. August, 1960. 46 p., frontis., 11 fig., bibliogr.

Volume 27, Article 6.—Sex Ratios and Age Ratios in North American Ducks. By Frank C. Bellrose, Thomas G. Scott, Arthur S. Hawkins, and Jessop B. Low. August, 1961. 84 p., 2 frontis., 23 fig., bibliogr.

Volume 28, Article 2.—The Fishes of Champaign County, Illinois, as Affected by 60 Years of Stream Changes. By R. Weldon Larimore and Philip W. Smith. March, 1963. 84 p., frontis., 70 fig., bibliogr., index.

Volume 28, Article 3.—A Comparative Study of Bird Populations in Illinois, 1906–1909 and 1956–1958. By Richard R. Graber and Jean W. Graber. October, 1963, 146 p., 4 frontis., 32 fig., bibliogr., index.

Volume 29, Article 1.—A Biological Investigation of the Fishes of Lake Chautauqua, Illinois. By William C. Starrett and Arnold W. Fritz. March, 1965. 104 p., frontis., 40 fig., bibliogr., index.

Volume 29, Article 2.—Stocking and Sport Fishing at Lake Glendale (Illinois). By Donald F. Hansen. July, 1966. 54 p., frontis., 9 fig., bibliogr., index.

CIRCULAR

39.—How to Collect and Preserve Insects. By H. H. Ross. November, 1966. (Eighth printing.) 71 p., frontis., 79 fig.

46.—Illinois Trees: Their Diseases. By J. Cedric Carter. June, 1964. (Third printing, with alterations.) 96 p., frontis., 89 fig.

47.—Illinois Trees and Shrubs: Their Insect Enemies. By L. L. English. October, 1965. (Third printing, with revisions.) 92 p., frontis., 59 fig., index.

48.—Diseases of Wheat, Oats, Barley, and Rye. By G. H. Boewe. June, 1960. 159 p., frontis., 56 fig.

49.—The Dunesland Heritage of Illinois. By Herbert H. Ross. (In cooperation with Illinois Department of Conservation.) August, 1963. 28 p., frontis., 16 fig., bibliogr.

50.—The Wetwood Disease of Elm. By J. Cedric Carter. May, 1964. 20 p., 19 fig.

51.—Illinois Trees: Selection, Planting, and Care. By J. Cedric Carter. August, 1966. 123 p., frontis., 108 fig.

52.—Fertilizing and Watering Trees. By Dan Neely and E. B. Himelick. September, 1966. 20 p., 9 fig., bibliogr.

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43.—Hot-Water and Chemical Treatment of Illinois-Grown Gladiolus Cormels. By J. L. Forsberg. March, 1961. 12 p., 8 fig., bibliogr.

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53.—Experimental Field Studies on Shade Tree Fertilization. By E. B. Himelick, Dan Neely, and Webster R. Crowley, Jr. June, 1965. 12 p., 8 fig., bibliogr.

54.—A Preliminary Annotated List of the Lampreys and Fishes of Illinois. By Philip W. Smith. June, 1965. 12 p., 3 fig., bibliogr.

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57.—Man's Effect on the Fish and Wildlife of the Illinois River. By Harlow B. Mills, William C. Starrett, and Frank C. Bellrose. June, 1966. 24 p., 16 fig., bibliogr.

58.—The Life History of the Slough Darter, *Etheostoma gracile* (Pisces, Percidae). By Marvin E. Braasch and Philip W. Smith. June, 1967. 12 p., 8 fig., bibliogr.

MANUAL

4.—Fieldbook of Illinois Mammals. By Donald F. Hoffmeister and Carl O. Mohr. June, 1957. 233 p., color frontis., 119 fig., glossary, bibliogr., index.

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