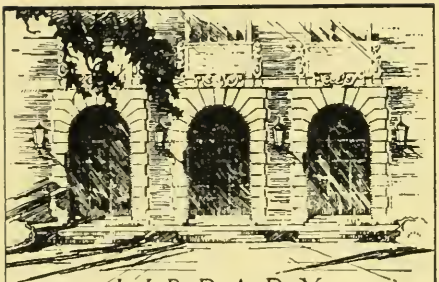

ILLINOIS TREES: THEIR Diseases

J. CEDRIC CARTER

ILLINOIS NATURAL HISTORY SURVEY

Circular 46

Third Printing,
With Alterations

STATE OF ILLINOIS
DEPARTMENT OF REGISTRATION AND EDUCATION
NATURAL HISTORY SURVEY DIVISION

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URBANA
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CONTENTS

The photographs reproduced in this circular were taken by the following persons: J. Cedric Carter, William E. Clark, Ray R. Hamm, Robert E. Hesselschwerdt, Charles L. Scott, and Wilmer D. Zehr. The drawings were made by Robert E. Teegardin. The cover photograph, by Dr. Carter, shows the first tree affected with Dutch elm disease found in Illinois.

Shoestring root rot frequently is found affecting
the roots of oak trees that show staghead.

ILLINOIS TREES: THEIR **Diseases**

J. CEDRIC CARTER

MOST KINDS OF TREES in Illinois are subject to one or more diseases. Some diseases cause little noticeable damage to the trees. Others, by severely injuring leaves, twigs, branches, or roots, cause stunting or, eventually, dying of the trees. The most virulent or destructive diseases, such as elm phloem necrosis, Dutch elm disease, and oak wilt, usually cause rapid dying of trees.

The value of trees for shade and ornamental purposes on lawns and in recreation areas, for windbreaks, for erosion control, or for lumber and other wood products may be greatly reduced or destroyed by disease. Also, the removal or destruction of trees killed by disease may be very costly to home owners, park districts, forest preserve districts, or municipal governments.

Most tree diseases that are of frequent occurrence in Illinois, or that are widespread or destructive here, are described in this publication. Included are diseases of both native and introduced trees. Information is given on prevention or control of these diseases.

WHAT CAUSES TREE DISEASES?

In a broad sense, diseases in trees are any conditions that alter or prevent the expected normal growth. They may be either infectious or noninfectious.

Infectious Diseases

The common causes of infectious diseases in trees are fungi, bacteria, and viruses. Other causes are a few of the higher plants.

Fungi.—The agents of the infectious diseases causing the greatest amount of damage to trees are fungi. They lack the green coloring matter called chlorophyll and are unable to manufacture their own food. They obtain nourishment from other living plants or from dead organic matter. Fungi that grow on, or in, a living plant are called parasites, and the living plant is called the host. Those that live on dead organic matter are called saprophytes.

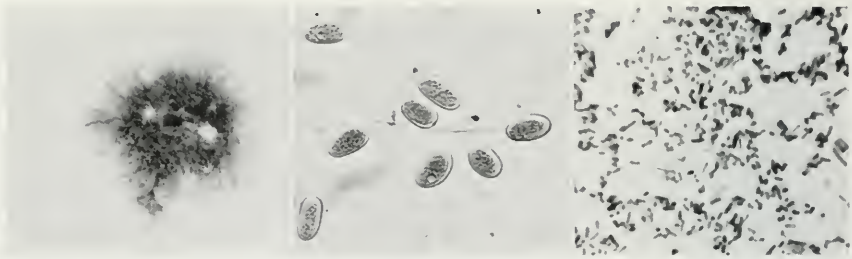


Fig. 1 (*left*).—Fungus mycelium is composed of fine, threadlike strands of entwined hyphae.

Fig. 2 (*center*).—Fungi reproduce by means of spores, which are microscopic in size and which vary in color, shape, and number of cells. The spores in this picture are oval, colorless, single cells which are produced by the fungus that causes Dothiorella canker of oak.

Fig. 3 (*right*).—Bacteria which cause plant diseases are very small, rod-shaped, single-celled organisms.

Fungi grow as very fine, threadlike strands, called hyphae, which branch and produce entwined masses of moldlike growth called mycelium (Fig. 1). The mycelium may grow within the host, or it may develop as powdery or moldlike growth on the surfaces of leaves or other parts of the host.

Fungi reproduce by means of spores, which are microscopic in size and which vary in color and shape (Fig. 2). These spores may be carried from diseased to healthy trees by wind, rain, pruning tools, insects, and other agents.

Bacteria.—Bacteria that cause diseases in trees are single-celled, rod-shaped, microscopic organisms (Fig. 3). They reproduce by simple division—one individual divides to become two individuals. Bacteria, like fungi, contain no chlorophyll and obtain their nourishment from other living plants or from dead organic matter. Also, like fungi, they may be carried from diseased to healthy plants by wind, rain, pruning tools, insects, and other agents.

Viruses.—Viruses are infectious agents that are too small to be seen with the highest power of the conventional compound microscope. However, they can be seen with the electron microscope. They appear to be protein in nature and are capable of reproducing themselves in living hosts. Many viruses are carried from diseased to healthy plants by insects. They may be transmitted artificially when parts of diseased trees are grafted on healthy trees.

Higher Plants.—The only one of the higher plants known to cause an infectious disease in Illinois trees is one of the mistletoes, *Phoradendron flavescens* (Fig. 4 and 5). Mistletoes, which are seed plants with green leaves, grow on trees and obtain nourishment from the sap by sending rootlike structures (haustoria) through the bark.

In southern Illinois, mistletoe frequently is found growing on elm and occasionally on oak, sycamore, black gum, honey locust, maple, and walnut. It occurs in 18 counties in southern Illinois; its range extends northward along the Wabash River into Clark County and northward along the Mississippi River into Randolph County. Mistletoe causes very little noticeable damage to trees in Illinois. Scattered clumps or bunches of mistletoe, conspicuous during the dormant season when trees

Fig. 4.—Mistletoe is a green, seed-producing plant that grows on living trees. It causes little noticeable damage to trees in Illinois. The two clumps of mistletoe shown above are on American elm.

Fig. 5.—Mistletoe attaches itself to a living tree. It obtains nourishment from the sap of the tree by sending rootlike structures (haustoria) through the bark.

are bare of leaves, may appear unsightly. However, mistletoe is famous for its sentimental and decorative values at yuletide.

Noninfectious Diseases

The common causes of noninfectious diseases in trees are unfavorable environmental conditions, chemical injuries, and mechanical injuries (Fig. 6–12).

Unfavorable Environmental Conditions. — Certain environmental conditions unfavorable to trees are associated with deficiencies or excesses of mineral elements in the soil. They cause physiological disturbances or disorders within trees. These dis-

Fig. 6.—Yellowing and wilting of foliage on trees may be caused by root injury from excavation of soil. Such injury to elms may produce foliage symptoms similar to those of phloem necrosis. Mechanical injury of this kind may cause dieback of branches or death of trees.

orders are called physiological diseases. A common type of physiological disease of trees in Illinois is chlorosis, often seen in the pin oak. This disease is usually associated with a deficiency of available iron in the soil. Other unfavorable environmental conditions are associated with weather—too much or too little moisture, too high or too low temperatures. The resulting dis-

Fig. 7 (*left*).—Sapsuckers, in feeding on the sap of trees, make bands of conelike holes in the bark of branches and trunks. These holes become larger and somewhat rectangular or square, as shown in this picture, as the injured tree continues to grow. Branches and trunks girdled by numerous rows of these holes may die.

Fig. 8 (*right*).—Mechanical injury to trees, especially to weakened or newly transplanted trees, may be caused by bark beetles, borers, and other insects. This picture shows galleries made by the smaller European elm bark beetle in a weakened elm.

orders are called weather or climatic troubles. Although these troubles cannot be prevented, in many cases their detrimental effects can be reduced by treatment.

Chemical Injuries.—Various chemicals, including herbicides, fungicides, insecticides, and fertilizers, may cause tree injury

Fig. 9 (*top*).—Girdling roots have killed some of the bark at the base of the trunk of this maple, as shown by the brown discoloration of inner bark where a narrow strip of outer bark has been removed. White living bark is visible at the top of the area from which the outer bark has been removed. Girdling roots may be so injurious that affected trees may show gradual decline and finally die.

Fig. 10 (*bottom*).—Trees used as posts for wire clotheslines or fences are in many cases girdled and killed by the wire.

when they are used improperly. Injury can be avoided by proper care in the application of such materials. Occasionally tree injury in caused by illuminating gas and by sulfur dioxide.

Fig. 11.—Trees, such as Siberian elm, with soft, brittle wood may be seriously damaged by coatings of ice.

Fig. 12.—The force of wind in tornadoes uproots many trees each year and causes inestimable damage to wooded areas. The wooded area shown above contained mostly oaks.

Mechanical Injuries.—Mechanical injuries to trees are caused by man (Fig. 6), birds (Fig. 7), or other animals, and by insects (Fig. 8), as well as by forces or conditions not influenced or controlled by man. Many of these injuries occur to the exterior of the tree, especially to the trunk. Most of the injuries caused by girdling roots (Fig. 9), axes or similar tools, ground fires, girdling wires (Fig. 10), nails driven into trunks, lawn mowers, and motor vehicles can be avoided. Most of the injuries caused by water, hail, ice (Fig. 11), snow, wind (Fig. 12), and lightning cannot be prevented by man. Damaged trees should be treated as soon as possible to reduce the amount of ultimate injury that might occur. Broken branches should be cut back to sound lateral branches or to where they are attached to the trunk. Injured bark should be cut back to uninjured bark. Exposed wood in wounds should be protected with wound dressing to prevent decay, as described under "Wound Treatment."

TYPES OF TREE DISEASES

Tree diseases are frequently classified according to the part of the tree which they attack or affect. On this basis they may be divided into leaf diseases, stem diseases, vascular diseases, and root diseases.

Leaf Diseases

Leaf diseases may be infectious or noninfectious. Most infectious leaf diseases are caused by fungi. Some are caused by viruses or bacteria. The infectious diseases may produce moldlike growths on the leaf surfaces, local lesions in the tissues, yellowing of the tissues between the veins, or death of entire leaves. Some of them may affect flowers, fruits, twigs, or young branches. They may cause very little permanent damage to deciduous trees unless infection occurs year after year. Severe leaf injury and defoliation for several successive years may weaken affected trees and make them more susceptible to attack by other diseases and by insects. Also, they may lower the resistance of trees to unfavorable weather conditions. Defoliation in late summer is less injurious than defoliation in early summer, since the annual tree growth is usually completed by late July. Defoliation of evergreens during a single growing season may cause severe dieback of branches or death of whole plants.

The names of many leaf diseases are descriptive of the types of injury produced, such as powdery mildew, spot, blotch, blight, rust, scorch, and chlorosis. Leaf diseases common to most species of trees are powdery mildew, leaf spot, scorch, chlorosis, and those resulting from chemical injuries.

Powdery Mildew.—This fungus disease, which usually appears in late July and August, produces an unsightly gray to white powdery covering on the leaves of affected trees. In many cases, small black dots, fruiting bodies of the fungus, are visible on the powdery growth. Although most trees are susceptible to this disease, it occurs infrequently and usually causes very little noticeable leaf injury. It can be controlled by applications of a sulfur fungicide at 10-day intervals after the first appearance of the disease.

The fungi that cause powdery mildew in Illinois, and the trees they affect, are as follows:

Microsphaera alni on catalpa, chestnut, elm, honey locust, oak, sycamore, and walnut

Microsphaera arineophila on beech

Microsphaera elevata on catalpa

Microsphaera diffusa on honey locust

Phyllactinia corylea on ash, birch, catalpa, elm, mulberry, and oak

Phyllactinia suffulta on ash, birch, and catalpa

Podosphaera leucotricha on crab apple

Podosphaera oxycanthae on wild cherry and hawthorn

Sphaerotheca lanestris (brown mildew) on white oak

Uncinula circinata on maple

Uncinula clintonii on linden

Uncinula flexuosa on horsechestnut and elm

Uncinula macrospora on elm

Uncinula salicis on poplar and willow

Leaf Spot.—Leaf spot diseases become conspicuous usually during July and August. Most of them are caused by fungi or by bacteria. Occasionally some of them deform or kill flowers, fruits, twigs, or young branches. Most leaf spot diseases develop as small, scattered, circular to oval, light to dark brown dead areas on the leaves (Fig. 13). Later, these spots may enlarge and unite to form large, angular to irregular dead areas. Minute black dots, fruiting bodies of the fungus, may appear embedded in tissues of the diseased areas. On leaves of some trees, spots may have red to reddish-brown margins, as on leaves of chestnut, linden, oak, poplar, and redbud. On leaves of other trees the spots may be bordered by purple, as on ash, crab apple, and

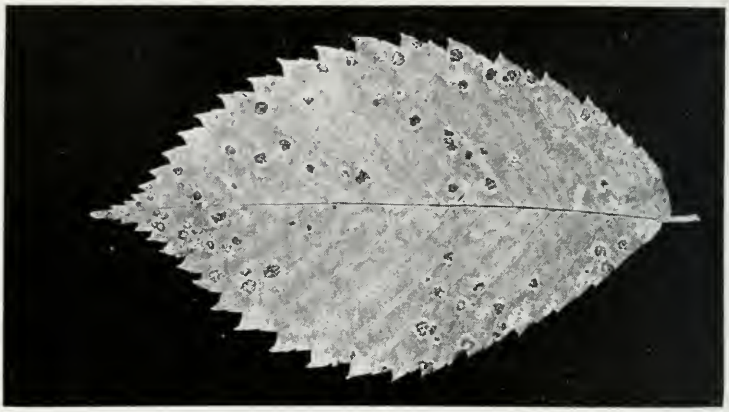


Fig. 13.—Leaf spot diseases produce small, scattered, circular to oval, brown dead areas in the leaves. Frequently two or more spots coalesce and form large, irregular diseased areas. On elm, shown in this picture, the leaf spot fungus produces numerous fruiting bodies on the brown diseased tissues; these fruiting bodies make the spots appear black and scab-like.

hawthorn. Spots on walnut leaves are large, dark brown, and round to oval. On cherry leaves the brown dead areas of tissue drop out in time, leaving a shot-hole appearance of the leaf. One leaf spot disease of crab apple and hawthorn produces minute purple specks soon after the leaves unfold; it is caused by the fungus *Physalospora obtusa*. The specks soon enlarge to form reddish-brown, circular to oval spots. After a few weeks, some of the spots may start to enlarge and to form concentric rings of dark brown, which give rise to the term frogeye. This fungus also produces black rot of fruit and cankers on twigs and branches.

Species of fungi that cause leaf spot diseases in Illinois belong to the following genera: *Alternaria, Ascochyta, Cercospora, Coccomyces, Coniothyrium, Cylindrosporium, Dothiorella, Gloeosporium, Gnomonia, Leptostroma, Marssonina, Microsphaerella, Monochaetia, Phyllosticta, Physalospora, Septoria,* and *Venturia*. The bacterium *Xanthomonas pruni* causes a leaf spot of chokecherry.

Several successive years of defoliation resulting from leaf spot disease may weaken affected trees and increase their susceptibility to other diseases. Such affected trees can be given plant food to stimulate vigorous growth. Leaves may be protected against leaf spot diseases by fungicides. Fungicidal sprays recommended for the control of some common leaf spot diseases are given in Table 1 (end of circular). Two or three applications should be made at 14- to 21-day intervals. The first spray should be applied approximately 3 weeks before spots appear on leaves, about June 15 for most leaf spot diseases in Illinois.

Infectious leaf diseases that affect one or a very few species of trees include leaf blotch, leaf blight, and leaf rust. Each of these diseases is described in the discussion of one of the trees on which it occurs.

Scorch.—This noninfectious disease may occur on any kind of tree. Ash, elm, and maple are frequently affected by it. Scorch develops as yellowing or browning of tissues between the veins or along the margins of leaves (Fig. 14), or as browning and withering of entire leaves. It may be caused by internal physiological disturbances, such unfavorable weather conditions as low temperature or drought, girdling roots, or soil area too limited for good growth. Frequently, scorch develops in July and August when the roots are unable to furnish sufficient water to compensate for the moisture lost from the leaves during prolonged dry periods. Drying winds when the temperature is high will increase the amount and severity of scorch. Trees affected

Fig. 14.—Scorch and chlorosis are noninfectious diseases associated with unfavorable environmental conditions. Scorch (*oak leaf at right*) develops as browning or yellowing between the veins or along the margins of leaves, or as complete browning and withering of leaves. Chlorosis (*center oak leaf*) is indicated by a pale yellowish-green color of the leaf tissue and normal green color of the midribs and veins. A normal oak leaf is shown at the left.

with scorch may lose many leaves during late summer; usually they do not die. Trees in low vigor may be aided in overcoming scorch by being fed and watered. Sometimes it may be advisable to remove interfering and weak branches from a tree and thereby reduce the total foliage load that must be supported by the root system.

Chlorosis.—Trees suffering from lack of available nutrients such as iron, magnesium, manganese, boron, zinc, and nitrogen usually show abnormal color of leaves or abnormal types of growth. Probably the most common type of deficiency disease is chlorosis, caused by the nonavailability of iron. Chlorosis frequently occurs in oak, especially pin oak, and sweetgum, and it occasionally occurs in other deciduous trees and in evergreens, especially pines. In pin oak and other deciduous trees, it develops as yellowing of tissues between the veins of leaves (Fig. 14). In a severe case, the leaves curl and turn brown along the margins, or they develop angular brown spots between the veins. Later the leaves and twigs may die; the affected tree may be stunted in growth or it may die. Chlorosis of pines usually develops as an overall yellowing of needles.

Chlorosis may develop because of unfavorable conditions for the utilization of iron in the tree or in the soil. Under alkaline conditions, or at a pH above 6.7, iron changes to insoluble forms. Iron is most readily available at a pH range of 5 to 6.5. Deficiency of available iron is aggravated by low temperature and high moisture, by relatively large amounts of copper, manganese, and zinc, by insufficient potassium, and by excessive application of phosphorus fertilizer. Frequently trees recover from chlorosis when they are supplied with available iron. The iron may be sprayed on the chlorotic leaves, introduced into the trunk, or added to the soil. Spraying the foliage thoroughly usually corrects chlorosis of the leaves that are treated, but it is not likely to benefit leaves produced after the iron has been applied. A spray composed of 5 pounds of iron sulfate (ferrous sulfate) and 2 pounds of soybean flour in 100 gallons of water is most effective when applied in late spring or early summer, during the time the leaves are increasing in size. Table 2 (end of circular) gives equivalent measurements for small quantities of spray.

Introducing iron into the trunk of an affected tree may correct chlorosis for several years. The tree may be treated through holes, each approximately one-half inch in diameter, bored in the trunk at an oblique angle; the holes should slant downward and penetrate the sapwood to a depth of only 1 or 2 inches. The iron, in the form of iron citrate, may be placed in the holes as a dry powder in large gelatin capsules or forced into the trunk in water solution by use of special equipment. The usual dosage is 5 grams of iron citrate per inch of trunk diameter. Best results from this method of treating are obtained when the iron citrate is applied before leaves appear in the spring.

More lasting results are obtained through soil treatment than through either of the treatments described above. Equal parts by weight of iron sulfate and sulfur are added to the soil. The sulfur is added to acidify the soil. Iron is changed to soluble forms in acid soil. To stimulate growth of chlorotic trees, the iron sulfate and sulfur should be supplemented with tree food, as described in the section "Feeding." The iron sulfate and sulfur mixture is supplied at the rate of 1 to 3 pounds per inch of trunk diameter at breast height. The heavier rate of application mentioned is for trees over 6 inches in diameter. Trees that do not respond to a single treatment should be retreated in succeeding years.

Chelated iron and other specially prepared iron compounds have been recommended as being more effective than iron sulfate for correcting chlorosis, especially in alkaline soils. These types of materials are sold under various trade names and should be used as recommended by the manufacturers.

Chemical Injury.—In recent years chemical injury to trees has become frequent, largely because of the common and widespread use of herbicides such as 2,4-D, and 2,4,5-T. Injury caused by spray drift or vapors of 2,4-D and 2,4,5-T appears as deformed growth or dying of trees. In mild cases of injury the leaves of some trees, such as elm, hackberry, hickory, honey locust, and oak, may become thickened and leathery; the tips and margins of the leaves may be cupped downward or the leaves may be rolled. More severe injury may cause leaves to grow long and narrow and the veins to appear unusually prominent. Severely injured leaves of cherry, birch, black locust, elm (Fig. 15), hawthorn, honey locust, Russian olive, sycamore, and walnut may become twisted or rolled and appear boat shaped or curled into ram's-horns. In time the leaves die. Many trees recover in succeeding years from mild injury caused by 2,4-D and 2,4,5-T. Feeding to stimulate growth may aid in their recovery. Severely injured trees may have many branches killed, or the trees themselves may die.

Fig. 15.—Leaves of trees sensitive to 2,4-D injury grow long and narrow, and the veins become unusually prominent. The severely injured English elm leaves in this picture have become twisted and rolled.

Injury to trees from applications of tree food, or fertilizer, has been observed on some trees, especially on oak affected with severe dieback of branches and on trees that have large areas of dead bark on the trunks. Such areas of dead bark, which may not show externally and may therefore be overlooked, usually can be detected if the trunk of an affected tree is tapped with a knife or ax for evidence of hollow areas. Fertilizer injury is indicated by browning and yellowing of leaves, especially along the margins and between the veins (Fig. 16). Young leaves may stop growing and appear dwarfed. Many fibrous roots may die. Loss of these roots greatly reduces the amount of food and water supplied to the foliage. Most mildly injured trees recover; many of them do not even lose their leaves. Most severely injured trees lose their leaves, and some of them die.

Natural gas is relatively nontoxic to trees. However, in large quantities it will displace the oxygen in the soil and cause suffocation of roots. Illuminating gas is toxic. Injury to trees from illuminating gas varies from mild to severe and is influenced by the amount of gas that reaches the roots from leaks in gas mains. Leaks are most apt to occur in old mains. It has been suggested that injury to the trees is caused by hydrogen cyanide, which, with water in the soil, forms hydrocyanic acid. Severe injury by gas usually shows as rapid wilting, browning, and death of leaves (Fig. 17), followed by withering of branches and death of the affected trees. Bluish-black discoloration of small roots on some trees can be detected after the bark is removed. On London plane trees, the inner bark may appear water soaked and pink, and long, narrow cankers may form in the bark at the bases of the trunks. A gas leak sufficient to cause severe injury to trees will kill grass, weeds, and shrubs in the vicinity of the leak; from such a leak, a strong odor of gas usually can be detected in the air. Most gas companies have machines that can detect even small quantities of gas in the soil.

Fig. 16.—Injury to trees from applications of excessive dosages of fertilizer shows as curling, yellowing, browning, and stunting of leaves. Irregular areas of tissues along the margins and between the veins turn brown and die. The living tissues between the veins become yellowish green, and the leaves are stunted, as shown by the two leaves on the right, in contrast to the uninjured leaf on the left.

Fig. 17.—A tree severely injured by illuminating gas usually shows rapid wilting, browning, and death of leaves, followed by dying of branches and death of the tree. In elms, gas injury may be mistaken for phloem necrosis.

Mild injury by gas is difficult to differentiate from other injuries, similar in appearance, that may be caused by some infectious diseases, nutritional deficiencies, high temperatures, too little or too much water, and internal physiological difficulties within a tree. Mild injury can be caused by leaks of 2 to 5 cubic feet of gas per day. A mildly injured tree shows irregular, yellow discoloration of many leaves, somewhat similar to that in chlorosis; discoloration is followed by premature falling of injured leaves and also of some green leaves. Later the tree produces another crop of small, light green leaves, and some twigs and branches may die. A gas leak that results in only mild injury to trees may or may not be sufficient to kill the surrounding grass and other plants.

A tree that is only slightly injured by gas may be saved by prompt treatment. The gas leak must be stopped, and the soil around the tree roots should have air forced into it to replace the gas. The day after aeration the soil should be thoroughly washed. A watering needle or lance may be used to supply sufficient water to saturate the soil and to force large quantities of the water out through the aeration holes and away from the root area of the tree. After the soil has returned to a normal air-water relationship, the tree should be fed. It may need to be fed annually for several years.

Injury to trees from sulfur dioxide occurs in areas where industrial plants, in utilizing sulfurous materials, liberate sulfur dioxide into the air. Injury is most apt to occur in clear weather when the humidity is 80 per cent or above, when the air movement is less than 5 miles per hour, and when the concentration of sulfur dioxide in the air is 3 parts per million or greater. Symptoms of injury decrease with increase in distance from the source of trouble.

Evergreens are more susceptible to this type of injury than deciduous trees, old or mature leaves are more easily injured than young or immature leaves, and weakened trees more readily burned than healthy, vigorous trees.

Sulfur dioxide produces two types or degrees of injury: acute and chronic. Acute injury may look worse than it is since the leaves of an affected tree show sharply defined discolored or bleached areas along the margins or between the veins. Acute injury caused by a single burn may retard growth, but usually an affected tree recovers from it. Repeated burning causes premature defoliation, which may be followed by reduction in the amounts of annual growth or by sudden death of the tree. Chronic injury develops more slowly and is less severe; leaves may be discolored but usually they remain on the tree, which is retarded in growth. Sometimes chronic injury causes slight reduction in growth but does not cause visible injury to the leaves.

Stem Diseases

Stem diseases, in branches or trunks, may develop as canker, dieback, gall, witches'-broom, or woodrot.

Canker.—Canker diseases produce localized dead areas in the bark of twigs, branches, and trunks of affected trees. These areas are oval to elongate in shape and vary from 1 or 2 inches to 1 or more feet in length. Cankers may enlarge until they girdle an affected stem; that part of the stem beyond the girdle dies. Cankers may develop as conspicuous sunken areas, as discolored areas of bark that are not depressed, or as diseased areas so inconspicuous that they cannot be detected by examination of the surface of the bark. The diseased bark of conspicuous sunken areas becomes fissured and cracks away from the surrounding living bark (Fig. 18). Ridges of callus may be produced by the living bark surrounding the cankerous areas. On trees having light-colored bark, diseased bark that does not become depressed may turn reddish brown. Such cankers are conspicuous because of the abnormal color of the diseased bark. Inconspicuous cankers may be revealed by removal of a thin outer layer of bark and exposure of the brown to black dead bark of the diseased areas

Fig. 18 (*top*).—The conspicuous, depressed canker on this branch of Chinese elm is surrounded by callus. The diseased bark, in which black fruiting bodies of the fungus are visible, is cracked and sloughing from the wood.

Fig. 19 (*center*).—Cankers may be evident only by discoloration of the bark or by the presence of bumps (pustules) in the diseased bark, as shown in this canker on mountain ash. In this canker, the underlying diseased bark shows alternate bands of light and dark brown, in contrast to the white color of living bark.

Fig. 20 (*bottom*).—Fruiting bodies of a fungus frequently break through the diseased bark surface and become conspicuous as black spots or bumps, as shown on this branch of red oak.

(Fig. 19). Some canker diseases may be indicated by the presence of fungus fruiting bodies in the diseased bark. These fruiting bodies may produce raised places or pustules in the bark (Fig. 19), or they may break through the bark surface and become conspicuous as black spots or bumps (Fig. 20).

Cankers confined to branches usually can be eliminated by removal of the affected branches. Some cankers on the trunks of trees can be successfully removed by surgery. Large or multiple trunk cankers may result in severe girdling and subsequent death of affected trees (Fig. 21).

Gall.—Gall diseases, appearing as growths on tree roots or stems, may be caused by fungi (Fig. 22), bacteria (Fig. 23), or viruses that enter the trees through wounds. Development of

Fig. 21 (*left*).—Cankers which continue to enlarge year after year may result in severe girdling and subsequent death of affected trees.

Fig. 22 (*right*).—Galls or tumors on stems of trees vary in size from small and relatively inconspicuous to very large and conspicuous. The large gall shown above is on a white oak.

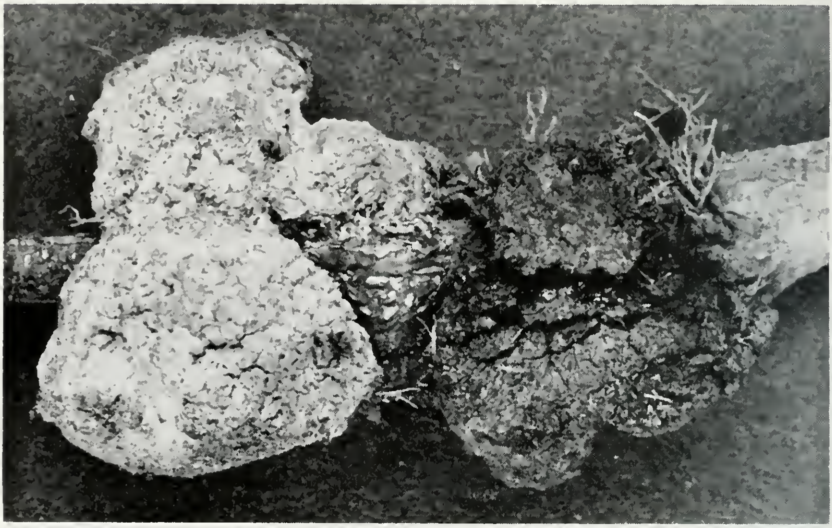


Fig. 23.—Crown gall, caused by bacteria, occurs usually at the base of an affected stem or on the large roots. The gall shown here is on a root.

Fig. 24 (*left*).—This elm is affected with dieback, as shown by the many branches with dead tips.

Fig. 25 (*right*).—Witches'-broom of hackberry is most conspicuous when the trees are without leaves.

galls interferes with sap flow and may cause stunting or death of trees. Wounds should be treated promptly to prevent infection.

Dieback.—Dieback is the gradual dying of a twig or branch from tip to base (Fig. 24). Frequently it develops on trees that are severely affected by canker diseases, especially on those branches girdled by cankers. Dieback may develop also on trees affected by conditions that reduce the amount of food and water below the minimum required for growth. Treatment for dieback includes removing all dead wood and supplying food and water to stimulate growth.

Witches'-Broom.—This disease produces broomlike growths, composed of clusters of shoots, on branches of affected trees (Fig. 25). Usually the shoots in these clusters are dwarfed; they grow from swollen or enlarged areas on the branches. The broomlike appearance is most conspicuous when the trees are without leaves. Witches'-brooms occur on both deciduous and evergreen trees; they are caused by fungi, viruses, mistletoes, insects, or mites. In Illinois, witches'-broom of hackberry is common.

Fig. 26.—Fruiting bodies or conks of the bracket-type, wood-rotting fungi frequently develop at wounds on the trunks or branches of trees. Infection by fungi occurs through such wounds. This picture shows conks of the white mottled rot fungus on white ash.

Woodrot.—Woodrot diseases, caused by fungi, produce decay of the wood of trunks and large branches. Decay usually develops slowly and may not noticeably shorten the life of an affected tree. However, it causes serious losses in the production of lumber and other wood products. Most wood-rotting fungi produce fruiting bodies of the bracket type (Fig. 26) or

Fig. 27.—Fruiting bodies of the mushroom-type, wood-rotting fungi may develop on the trunks of trees or in litter around the bases of trees.

the mushroom (toadstool) type (Fig. 27). Because these fungi enter trees mainly through unprotected wounds, it is important to treat wounds promptly to prevent infection.

Vascular Diseases

Most vascular diseases are caused by infectious agents (fungi, bacteria, or viruses) which invade the tree and develop in the sapwood or inner bark. These diseases may cause the leaves on one or more branches to wilt and die or the entire tree to die. Fungi and bacteria that cause wilt usually produce discoloration of the young sapwood, especially that of the current season wood. This discoloration, usually brown, may appear as streaks or as diffused discoloration of individual wood rings. Two destructive wilt diseases caused by fungi are Dutch elm disease and oak wilt. The only widespread and destructive wilt disease of trees caused by a virus is phloem necrosis of elm.

Root Diseases

Root diseases, some of which produce abnormal growths or tumors on the roots, may weaken or kill the roots of affected trees. Infectious agents that produce root diseases include fungi, bacteria, and viruses. Shoestring root rot, a fungus disease, is one of the common root diseases of trees that have previously been weakened or injured. Loss of roots from this disease deprives affected trees of sufficient food and water for normal growth and frequently results in branch dieback and staghead (frontispiece).

DIAGNOSIS OF TREE DISEASES

In some tree diseases, the causes may be determined readily by careful examination of the affected parts. For example, the fungi that cause certain leaf diseases may produce conspicuous gray to white powdery growth on the surfaces of affected leaves or they may produce circular to irregular, brown, dead areas in the leaves. These diseased areas may have visible bumps or pustules in the affected tissues. In many other tree diseases, the causes are obscure and may not be found on or in the portion of a tree that shows disease. In wilt diseases, for example, the leaves wither and die, but the organism that causes wilt is in the sapwood of the stem. An accurate diagnosis can be made only after sufficient evidence and information about the tree and its surroundings have been obtained to develop a complete case history of the trouble.

TOOLS AND THEIR USES

Tools useful for examining trees suspected of being diseased include pocket knife, hand shears, leather punch, saw, hatchet or ax, shovel, increment borer, reading glass or hand lens, and field glasses (Fig. 28). The leaves and branches of small trees may be reached from the ground and examined for diseases. On trees so tall that the leaves and branches cannot be reached from the ground, injury to leaves, cankers on branches, or other signs of disease frequently can be detected with field glasses.

To determine the specific agent or type of agent causing the trouble, it is necessarv in most cases to obtain a sample or sam-

Fig. 28.—Tools useful in examining trees for diseases include knife, hand shears, saw, hatchet or ax, reading glass, hand lens, extension pruner, punch, increment borer, field glasses, and shovel.

ples of the affected part. In some cases, suitable samples can be obtained with an extension pruner. These samples can be examined for bark troubles caused by diseases and mechanical injuries and for sapwood discoloration caused by wilt diseases, including Verticillium wilt, Dutch elm disease, and oak wilt. Bark samples from the trunk of a tree can be obtained with a knife,

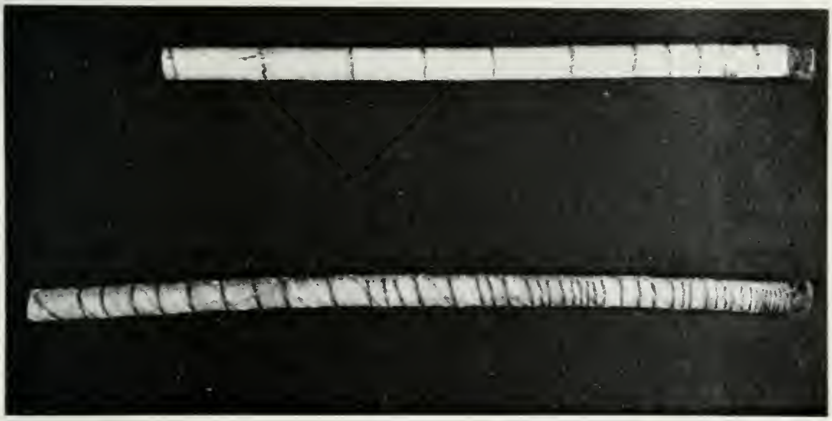


Fig. 29.—These cores or borings of wood, from the trunks of different trees, are marked to show the amount of wood produced each year. The core with broad annual rings of wood is from a healthy, fast-growing elm. The core with narrow rings is from an elm that grew slowly for many years and that had numerous branches dying during the last 6 years of growth. The fast-growing elm produced as much wood in 10 years as the slow-growing elm produced in 40 years. During the period when branches were dying on the slow-growing elm, the amount of wood produced in 6 years by this tree was equal to the amount of wood produced in 1 year by the fast-growing elm.

hatchet, ax, or leather punch. Samples adequate for detecting the symptoms of elm phloem necrosis, for example, can be taken with the punch, which does not injure the sampled tree excessively. A punch, size 8, 10, 12, or 14, makes a small, round hole that is soon plugged with callus tissue.

For diagnosis of some tree troubles, it is desirable to obtain samples of the trunk wood. A core or boring of wood (Fig. 29) can be obtained from the trunk of a tree with an increment borer. The amount of wood produced each year by the tree will be indicated by the width of each annual wood ring in the core. Examination of the core can determine whether growth has been normal each year, whether it has decreased or increased over a period of years, whether it has stopped abruptly in the current year. A gradual decrease in the amount of wood produced each year may be caused by grade changes of the earth near the tree, limited space for root growth, girdling roots, root injury from excavation or other soil disturbances, or root diseases. A shovel is useful for making examinations for various root troubles.

TREE THERAPY

Spraying, pruning, feeding, watering, and sanitation are used in combating tree diseases. Some diseases may be avoided by use of resistant or immune varieties of trees.

The effectiveness of a spray may be increased by elimination of the source of the infectious agent that the spray is designed to control and by removal and burning of diseased twigs and branches. Removal of a few trees in dense plantings, to increase aeration, may aid in controlling some diseases. Trees severely weakened by repeated attacks of disease may be given plant food to stimulate vigorous growth.

Since many diseases controlled by fungicides do not cause serious damage each year, it is not necessary to spray annually for their control. For this reason, the spray chart at the end of this circular (Table 1) does not represent a spray schedule to be followed each year. It is given to show the relationship between the time of year and the approximate time at which sprays should be applied for control of certain tree diseases under Illinois conditions. The diseases are listed in the order in which they occur during the growing season. Since sprays are applied to the surfaces of plants, they act as barriers or protectants against germs and are of major importance against leaf diseases. Equivalent measurements for small quantities of spray are given in Table 2 (end of circular).

Spray Materials

Most sprays contain materials poisonous to man and other animals and should be used in the manner and at strengths recommended by the manufacturer or as specified in Table 1 (end of circular).

Copper Sulfate and Hydrated Lime.—In combination with water commonly called Bordeaux mixture. Copper sulfate can be purchased as crystals, granules, or powder. The powder is most convenient for use in spray mixtures.

The instant method of mixing Bordeaux is commonly used. To prepare 100 gallons of an 8-8-100 formula of spray, fill the sprayer tank two-thirds full of water. Start the agitators and keep them running while slowly sifting in 8 pounds of copper sulfate and then 8 pounds of lime. Finish filling the tank with water. Use the spray mixture immediately. A sticker, such as soybean flour, 4 ounces to 100 gallons of spray, will increase the effectiveness of Bordeaux and other copper sprays.

Copper compounds sold under various trade names may be substituted for Bordeaux mixture.

Cycloheximide.—An antibiotic fungicide sold under such trade names as *Acti-dione* and *Actispray*. It kills the spore-horns on the galls of the cedar-apple and cedar-hawthorn rusts and it controls leaf blight of hawthorn.

DDT.—A chlorinated hydrocarbon insecticide. Formulations of DDT are sometimes recommended for the control of the insect vectors of phloem necrosis and Dutch elm disease. Several concentrates of these formulations are on the market. Application of foliar DDT sprays over a period of years may bring about population increases of harmful insects and mites. Other chemicals may be needed to control these pests. DDT is hazardous to birds and other wildlife. In its use, special care should be exercised to hold bird losses to a minimum. Feeding stations, watering places, and other places frequented by birds should be protected from spray drift and run-off. Bird baths should be cleaned following spraying. Collection of spray in puddles, likely to occur when hydraulic sprayers are used, should be eliminated. In spite of these precautions, it is probable that birds will be killed, especially robins early in the season. Spraying should be undertaken with the prior knowledge that such losses may occur. Methoxychlor is much less hazardous to birds and other warm-blooded animals and it can be substituted for DDT. Although a methoxychlor spray costs two to three times as much as a DDT spray for material, the cost of labor in applying each spray is the same.

Dichlone.—A fungicide sold under the trade name *Phygon XL*. It controls black leaf spot of elm when it is used under Illinois conditions.

Dodine.—A fungicide recommended for the control of scab of crab apple, hawthorn, and mountain ash and leaf blight of hawthorn. It is sold under the trade name *Cyprex*.

Ferbam.—A fungicide sold under such trade names as *Fermate, Karbam Black,* and *Niagara Carbamate*. It is used for the control of rusts on juniper, hawthorn, and crab apple and for the control of powdery mildew.

Methoxychlor.—A chlorinated hydrocarbon that can be substituted for DDT. It is much less hazardous to birds and other warm-blooded animals. Although methoxychlor is two or three times as expensive as DDT, the cost of labor in applying the spray is the same.

Organic Mercury.—A fungicide sold under such trade names as *Puratized Agricultural Spray* and *Coromerc*. Under Illinois conditions, it controls sycamore anthracnose and some other leaf diseases.

Sulfur.—A fungicide that can be obtained in several forms. Sulfur is sold under various trade names.

Thiram.—A fungicide sold under the trade name *Thylate Thiram Fungicide*. It is recommended for the control of rusts on crab apple and hawthorn.

Zineb.—A fungicide sold under such trade names as *Parzate* and *Dithane Z-78*. It controls leaf blotch of buckeye and horsechestnut.

Feeding

To maintain the health and to promote the vigorous growth of shade and ornamental trees, it often becomes necessary to provide food materials that are lacking from the soil, or are present in insufficient amounts. In the forest, where humus accumulates year after year, trees are liberally supplied with organic material derived from decaying leaves and plants. This material serves as food and helps to retain soil water. Since, along city streets, in lawns, or in parks, natural sources of food and water often are insufficient, artificial feeding and watering are frequently necessary. Well-fed trees appear to be more resistant to drought than those that lack proper nourishment.

Three chemical elements, nitrogen (N), phosphorus (P), and potassium (K), must be available in the soil to insure the best development of a tree. The levels at which these elements are available, which vary greatly from place to place in Illinois, can be determined by soil tests. An efficient and economical tree food for a particular situation contains the essential elements only in the amounts needed to correct soil deficiencies.

A complete tree food, which should ordinarily be used if soil tests are not made, should contain all three essential elements. Nitrogen can be supplied by inorganic compounds—nitrate of soda, ammonium sulfate, calcium nitrate—or by organic materials—urea, soybean flour, cottonseed meal, tankage, dried blood, pulverized sheep manure. Phosphorus can be furnished as superphosphate and potassium as muriate of potash. Although an effective tree food can be prepared from inorganic materials alone, more lasting effects are obtained when one-third to one-half of the nitrogen is supplied by organic materials.

There is no established rule as to the amounts of nitrogen, phosphorus, and potassium a tree food must contain. In fertilizer formulas, nitrogen is expressed as nitrogen (N), phosphorus as "phosphoric acid" (P_2O_5), and potassium as potassium oxide or potash (K_2O). Prepared tree foods, some designed for dry feeding and some for liquid feeding, can be purchased ready for use through local dealers in fertilizers.

Tree foods designed for dry feeding commonly contain available N, P_2O_5, and K_2O in proportions of 12-6-4, 10-8-6, 10-6-4, 10-3-3, or 8-5-3. A 10-8-6 fertilizer is 10 per cent available N, 8 per cent available P_2O_5, and 6 per cent available K_2O.

Some of the tree foods designed for liquid feeding contain N, P_2O_5, and K_2O in proportions similar to those of dry foods. Others have these constituents in proportions of 23-21-17, 21-18-17, 20-20-20, 19-28-14, and 15-15-15.

A common method of determining the amount of tree food needed for a specimen tree is based on the amount of nitrogen required to maintain uniform growth of the tree. To calculate the amount of a 10-8-6 formula tree food required to give 6 pounds of nitrogen, divide 6 by 0.10 (10 per cent available nitrogen). The amount needed is 60 pounds. A few examples of the amounts of tree food needed by trees of different kinds and sizes are given in the sections "Feeding Rates for Deciduous Trees" and "Feeding Rates for Evergreens."

Tree feeding can be done at any time of year, but feeding during April, May, October, or November, when the soil contains ample moisture, is especially beneficial. Tree foods are not available except when in water solution; hence, it is highly desirable that, at the time of application of tree food in dry form, sufficient water should be present in the soil to dissolve the food.

To be effective, tree food must be placed where it is readily available to the roots, as described in the sections "Dry Feeding" and "Liquid Feeding."

When the feeding of trees is repeated over a period of years, the amounts of phosphorus and potassium should be reduced, because these two materials do not leach from the soil. Nitrogen is readily soluble in water, and any that is not quickly utilized by tree roots soon leaches away. After the need for annual applications of phosphorus and potassium has passed, annual applications of nitrogen may be needed to maintain vigorous tree growth.

Dry Feeding.—When being applied to a very small tree (less than about one-half inch in diameter near the base), tree food in dry form may be scattered on top of the soil around the tree and worked in with a hoe or soaked in with water.

Dry feed for a larger tree is commonly placed in holes 1½ to 2 inches in diameter and 18 to 24 inches deep. Make the holes with a punch-bar or soil auger, spacing them 24 to 30 inches apart in concentric circles around the trunk (Fig. 30). The outermost circle should be somewhat beyond the limit of branch spread and the inner circles should be spaced to maintain the required distance between the holes. Holes may be within 3 to 5

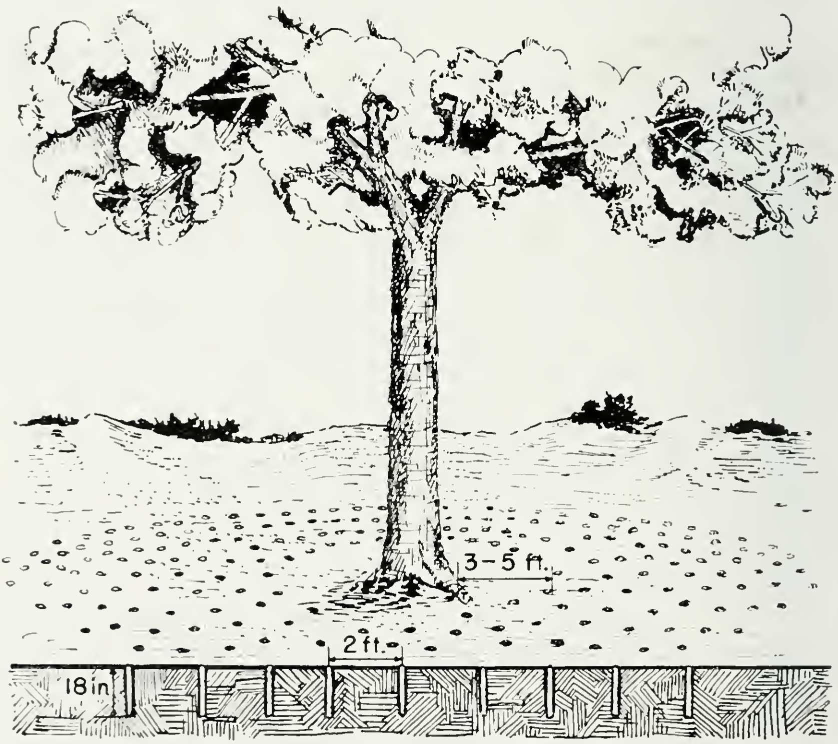


Fig. 30.—Dry tree food may be supplied to a tree through holes in the soil arranged in concentric circles around the trunk. These holes, 1½ to 2 inches in diameter, 18 to 24 inches deep, should be 24 to 30 inches apart.

feet of the trunks of large trees to supply the feeding roots there. Distribute the tree food evenly in the holes. Then fill the holes with water and keep them filled for about 3 days to soak the tree food into the soil and make it quickly available to the feeding roots. The holes may then be filled with sand, peat moss, or loose soil. Or they may be left open to facilitate water absorption during rains, aerate the soil, promote development of feeding roots, and provide a means of supplying water during droughts.

Liquid Feeding.—Tree food can be applied in liquid form with a sprayer (Fig. 31) that develops sufficient pressure to

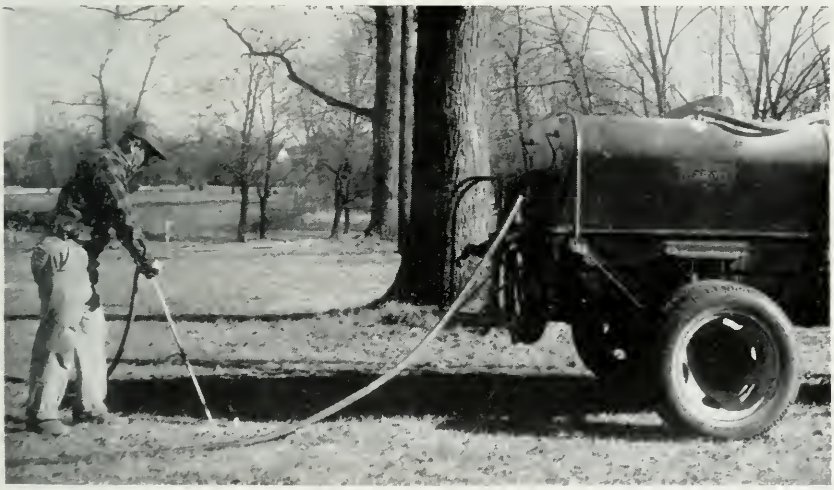


Fig. 31. — Hydraulic sprayers that develop several hundred pounds pressure can be used in liquid feeding of trees.

force the liquid into the soil. The only special piece of equipment needed is a feeding lance or gun (Fig. 32) that replaces the standard spray gun. A feeding lance may be purchased from a seed store, hardware store, or arborist supply store, or it may be devised by almost anyone handy with tools.

Liquid feeding of trees can be done from early spring until late fall. The tree food should be released in the soil 12 to 18 inches below the surface. Injections should be made 4 to 6 feet apart in concentric circles around the trunk of a tree. The outer circle of injection holes should be somewhat beyond the limit of branch spread; the innermost circle may be 3 to 5 feet from the trunk if the tree has a trunk diameter at breast height of 6 inches or more.

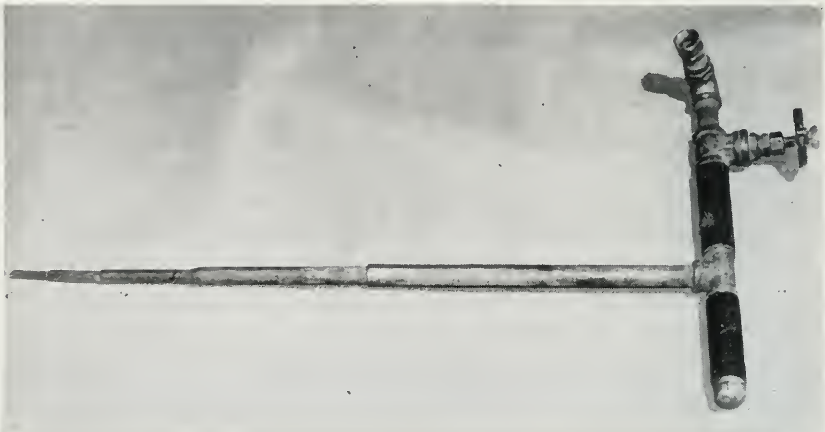


Fig. 32.—Feeding guns or lances can be devised by an ingenious individual who wishes to apply liquid plant food to his trees. Several types of these devices are manufactured and can be purchased.

A tree food consisting principally of highly soluble forms of nitrogen, phosphorus, and potassium should be used in liquid feeding. The food, in dry form, is added to water in the spray tank. Then each tree is fed the necessary number of gallons of solution to supply the required amount of food. The manufacturer's dosage recommendations should be followed. Safe dosages of most tree foods used in liquid feeding appear to be 1 to 3 pounds of the material per 5 inches of trunk diameter at breast height. The amounts of the less highly soluble materials, such as 10-8-6 and 10-6-4, needed for liquid feeding are the same as for dry feeding.

Feeding Rates for Deciduous Trees.—A deciduous tree having a trunk of less than 6 inches in diameter at breast height should receive one-fourth pound of available nitrogen per inch of trunk dbh. Larger trees should receive one-half pound of available nitrogen per inch of trunk dbh. Formulas of several tree foods, for dry or liquid feeding, are given on page 29. A tree with a trunk of 4 inches dbh requires one-fourth pound per inch, or 1 pound, of available nitrogen. A tree with a trunk of 12 inches dbh requires one-half pound per inch, or 6 pounds, of available nitrogen. The method of calculating the amount of tree food needed is described on page 29. The amount of 10-8-6 tree food required to supply 1 pound of available nitrogen is 10 pounds ($1 \div 0.10$). The amount of 12-6-4 tree food required to give 6 pounds of available nitrogen is 50 pounds ($6 \div 0.12$).

Feeding Rates for Evergreens.—Small evergreens planted in beds or closely planted in rows should have applications of soybean meal or cottonseed meal at the rate of 5 to 6 pounds per 100 square feet of ground surface, or applications of 10-6-4 or 8-5-3 tree food at the rate of 2 to 4 pounds per 100 square feet. The tree food should be worked into the topsoil with a hoe or soaked in with water.

Specimen evergreens of such kinds as pine, spruce, fir, and cedar can be fed tree foods having the formulas mentioned in the section "Dry Feeding." For small shrubby types, apply the plant food twice a year, in early spring and about June 15, at the rate of one-half pound to 1 pound per plant. For large specimen trees, apply the food once a year, in early spring or in the fall, at the rate of 2 to 2½ pounds per inch of trunk diameter at breast height. Place the food in holes beneath the branch spread (Fig. 30). The holes should be made with a soil auger or punch-bar—15 holes for each inch of trunk dbh, each hole 1½ to 2 inches in diameter and 12 to 15 inches deep.

Watering

Although shade trees generally do well in Illinois without special watering, lack of water in drought years or as a result of temporary or permanent lowering of the soil water table can cause serious injury and bring about death of the trees. Watering the ground surface beneath trees does little good. But applying water through a grid of holes reaching to the root level (holes such as are required for tree feeding) is effective. Watering lances (Fig. 32) offer a convenient means for soaking the soil around tree roots. Generous waterings at 2- to 3-week intervals give better results than frequent light waterings.

Pruning

Pruning can be done to improve the shape and general appearance of trees, to remove branches and stems damaged by wind, ice, and other types of mechanical agents, and to eliminate diseased and dead twigs and branches. In pruning branches, avoid ugly wounds caused by splitting of wood and tearing of bark. In removing branches too large to hold with one hand, make three separate cuts as shown in Fig. 33. First, make the undercut, *A*, 12 to 18 inches out from the main stem. Then make the overcut, *B*, 2 to 3 inches farther out. These two cuts will cause the branch to break off by its own weight. Complete the pruning by the final cut, *C*, which removes the stub flush with the main stem. Avoid tearing the bark down at the bottom of the final cut. Protect the wound with a wound dressing. Most wound dressings are composed mainly of asphaltum.

Pruning by topping or dehorning (Fig. 34) is more detrimental than beneficial to trees. It stimulates abundant sucker or

Fig. 33.—The method of pruning branches indicated here will avoid tearing the bark and making ugly wounds on trees. The first cut is made at *A*, the second at *B*. The third cut, at *C*, is made flush with the trunk of the tree.

watersprout growth that produces a thick crown of slender, weak branches. It creates large wounds that do not callus over. The wood exposed by these wounds is subject to wood rot.

Sanitation

As generally understood, sanitation consists of removal and destruction of dead or diseased trees or tree parts that may serve as breeding material for infectious agents or for insects that carry infectious agents. It is an important part of disease control.

In the control of some diseases, sanitation includes removal of one of the alternate hosts of the diseases. For example, currants and gooseberries are removed in the control of white pine blister rust since the white pine blister rust fungus must go to currants or gooseberries before it can reinfect white pines.

Wound Treatment

Wounds resulting from mechanical injuries or canker diseases can be treated as follows. Remove all of the diseased or injured bark (Fig. 35). With a chisel, remove all discolored wood and sufficient living bark from around each wound or diseased area to give an oval or egg-shaped area of exposed wood (Fig. 36). The long axis of the oval should be lengthwise of the stem, since bark grows laterally over wounds. To prevent drying and injury of the living bark, paint the cut edges of the bark with shellac or wound dressing immediately after shaping the wound. As soon as the material applied to the edges of bark is dry, use denatured alcohol to disinfect any exposed wood from which

Fig. 34.—Topping or dehorning usually is more detrimental than beneficial to trees. It creates large wounds that do not callus over.


Fig. 35 (*left*).—When a canker is removed, the diseased area should be traced back to living bark. Edges of the living bark should be painted with shellac or wound dressing to prevent drying of living tissues.

Fig. 36 (*right*).—After the edges are painted, all of the discolored or diseased bark is removed with a chisel or other sharp tool.

cankers have been removed. After the disinfectant has dried, paint the exposed wood with wound dressing (Fig. 37). Wounds may need repainting once or twice a year to insure complete protection from wood rot fungi and other wood-destroying agents (Fig. 38). To prevent spreading infectious agents to other trees, disinfect the tools used in pruning diseased trees. Denatured alcohol, used as a spray or dip, is a satisfactory disinfectant.

Resistance and Immunity

Whenever it is feasible to do so, species of trees resistant or immune to diseases should be used. Spiny Greek juniper, Hill juniper, and Keteleer red cedar are reported to be resistant to juniper blight. Other selections of red cedar have been reported that show resistance to cedar-apple rust. Varieties of chestnut have been developed which are resistant to chestnut blight. The

Fig. 37 (*left*).—The exposed wood is disinfected with denatured alcohol and painted with a wound dressing.

Fig. 38 (*right*).—Wounds may need to be repainted once or twice each year with a wound dressing to prevent wood rot fungi from attacking the exposed wood. This picture shows fruiting bodies of the wood-rotting sulfur fungus growing on exposed wood of a wound which has been treated with only one application of a wound dressing.

Christine Buisman and the Bea Schwarz seedling selections of elm are resistant but not immune to Dutch elm disease. Diseases for which resistant varieties or selections of trees are being tested include oak wilt, elm phloem necrosis, white pine blister rust, mimosa wilt, and poplar cankers.

ARBOR-VITAE

Arbor-vitae or white cedar trees are relatively free from parasitic diseases but are affected occasionally by winter drying.

Winter Drying.—This trouble, also called winter injury, frequently appears in late winter or early spring. It develops as extensive browning and death of foliage on 1-year-old or older shoot growth. Often it kills branches and, occasionally, entire trees. Winter drying frequently appears after periods of rapid changes in temperature, especially when a rapid rise in temperature has been accompanied by drying winds. As the air temperature rises, an excessive amount of water is given off through the needles. When water in the stem of a tree or in the soil around it is frozen, an insufficient amount of water is obtained through the roots to replace the water given off by the needles. Lack of water in the plant creates a form of drought which results in winter injury. Mulching in early fall to prevent deep freezing and to maintain a sufficient amount of water in the soil will aid in preventing winter injury. Small trees in windy or sunny locations may be protected from wind or sun by shields of burlap or other suitable material. Injured trees should be given plant food, as described in the section "Feeding," to stimulate growth. Dead wood should be removed after buds open in spring.

ASH

Ash trees occasionally are affected with anthracnose, leaf spot, scorch, powdery mildew, rust, wood rot, and a few minor canker and dieback diseases.

Anthracnose.—Ash anthracnose, caused by the fungus *Gloeosporium aridum*, results chiefly in destruction of leaf tissue. It produces large, irregular brown areas, especially numerous along the margins of the leaves. It is neither abundant nor destructive in Illinois during most years, and, except in unusual cases, requires no treatment. It can be controlled by sprays of organic mercury or copper fungicides (Table 1, end of circular). One or two applications of spray should be effective. Leaves from affected trees should be burned in autumn to eliminate the main sources of overwintering inoculum.

Scorch.—Many ash trees show leaf scorch annually, especially trees growing under adverse conditions. Some affected trees may lose their leaves and appear dead by August. Scorch is discussed under "Types of Tree Diseases." Feeding and watering to stimulate root growth and pruning to reduce total foliage growth may aid trees to overcome scorch.

Rust.—Rust, caused by the fungus *Puccinia peridermiospora*, occurs occasionally on leaves of ash trees, but it is usually of very little significance. It causes distortion of leaves and swelling of twigs. The alternate hosts of this rust are marsh and cord grasses. Rust appears infrequently and causes insufficient damage to require control treatment. Eradication of marsh and cord grasses near ash trees will disrupt the life cycle of the fungus.

Cankers.—Three fungi, *Physalospora obtusa, Cytospora* sp., and *Phomopsis* sp., cause canker diseases of ash. Frequently, these fungi attack the trunks and branches of weakened trees and cause severe damage. Healthy trees usually are not affected by them. Dying of portions of branches, of entire branches, or of entire sections of affected trees may be an indication of canker disease. Affected trees may be saved if given food and water to stimulate more vigorous growth in early stages of the disease. Affected branches should be removed and burned. The diseased portion of an affected branch is indicated by discolored or dead bark or by streaks in the wood, especially in the current-season wood.

White Mottled Rot.—This disease, caused by the fungus *Fomes fraxinophilus,* is a white mottled rot of the heartwood of both green ash and white ash. It affects the trunks of mature trees and dead trees. In early stages of the disease, small areas of the wood of affected trees are discolored brown. White spots soon appear in the discolored wood. In advanced stages of the disease the affected wood is soft, crumbly, and straw colored, mottled with white.

The fungus produces large, woody, perennial, hoof-shaped fruiting bodies or conks on trunks of affected trees (Fig. 26). The typical conk, up to 1 foot or more in width, is dark brown or black on the upper surface and straw-colored on the under surface. The fungus enters the trees through stubs left by the breaking off of dead branches and through wounds of various kinds. All dead and dying branches should be carefully removed in such a way as to prevent further infection, and all wounds should be protected with a wound dressing, as described in the section "Wound Treatment." Additional applications of wound dressing may be needed annually.

BIRCH

Birch trees weakened by infestations of bronzed birch borer or by unfavorable environmental conditions frequently are attacked by canker-producing fungi.

Cankers.—Several fungi, *Cytospora ambiens* (*Valsa ambiens*), *Melanconium betulinum, Nectria ditissima, N. cinnabarina, Sphaeropsis alnicola,* and *Valsa betulina,* may cause cankers on trunks and branches of birch trees. Melanconium canker occurs most frequently and may contribute to the death of individual branches or entire trees.

Canker diseases frequently can be overcome by the cutting out of diseased parts, followed by the feeding and watering of affected trees to stimulate vigorous growth. However, trees severely affected and trees growing in unfavorable sites probably will not respond favorably to treatment.

BUCKEYE AND HORSECHESTNUT

Buckeye trees and horsechestnut trees in Illinois are affected almost every year by leaf blotch, but they are relatively free of other diseases. Occasionally they are affected by scorch.

Leaf Blotch.—This disease is caused by the fungus *Guignardia aesculi*. It produces, on the affected leaflets, small to large, irregular reddish-brown areas with narrow yellowish margins (Fig. 39). The diseased areas of an affected leaflet may be confined to the margins or to tissues between the veins, or they may cover most of the leaflet, including midrib, veins, and tissues between the veins. In time, the whole leaflet may turn brown and fall prematurely. Fruiting bodies of the fungus appear as black specks on the diseased tissues. Trees severely defoliated for sev-

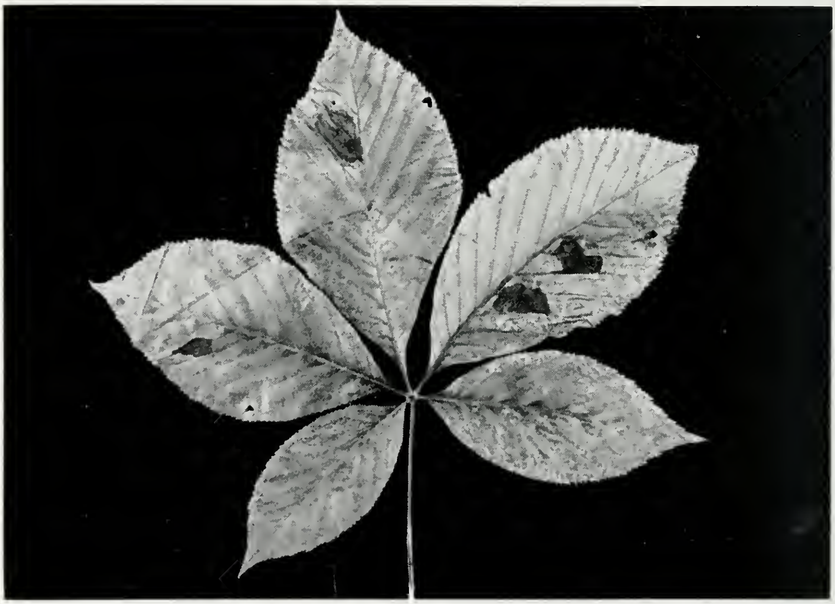


Fig. 39.—Leaf blotch of horsechestnut and buckeye causes small to large reddish-brown areas with narrow yellowish margins to form on individual leaflets. Extensive blotching of leaflets results in premature defoliation in late summer.

eral successive years may become stunted. Two or three thorough applications of a fungicide, either dodine or zineb (Table 1) at 10- to 14-day intervals, will help to prevent defoliation. The first spray should be applied when the leaf buds are opening. Trees severely defoliated for several successive years can be given plant food to stimulate vigorous growth, as described in the section "Feeding." Leaves from affected trees should be burned in autumn to eliminate the main source of the fungus, which overwinters in fallen leaves.

Buckeye and horsechestnut trees planted in Illinois should, whenever feasible, be varieties that have shown resistance to leaf blotch. A list of these may be obtained from the Illinois Natural History Survey.

Scorch.—Foliage scorch occurs on buckeye and horsechestnut trees occasionally during July and August. It is most likely to occur on trees growing under adverse conditions. Scorch is described under "Types of Tree Diseases." Feeding and watering may aid trees in overcoming the effect of scorch.

CATALPA

Catalpa trees occasionally are affected by powdery mildew and leaf spot. However, most damage to these trees is caused by a vascular disease called Verticillium wilt.

Verticillium Wilt.—This vascular disease of western catalpa is caused by the fungus *Verticillium albo-atrum*. Affected trees may have one to several branches wilt occasionally or for several years in succession. Loss of many branches destroys the ornamental value of a tree. Some trees affected with wilt may die within 1 or 2 years; others may live for many years (Fig. 40). The treatment for trees affected with Verticillium wilt is given in the section on maple.

CHERRY

Wild cherry trees are affected occasionally by leaf diseases and stem diseases.

Rust.—The fungus *Tranzschelia pruni-spinosae* causes leaf rust on chokeberry, wild black cherry, and wild red cherry. The small, dark brown to black spots produced on leaves are relatively inconspicuous. Rust causes insufficient foliage injury to require spraying.

Brown Rot.—This disease, caused by the fungus *Monilinia fructicola*, produces a limited amount of blossom blight and twig dieback on wild black cherry. In blossom blight, the flowers turn brown prematurely and wither or appear soft and rotting. Twig dieback appears as drying and death of young twig tips. Cutting out affected branches as soon as they are found will usually give satisfactory control.

Twig Canker.—The fungus *Valsa leucostoma* attacks weakened cherry trees. It produces cankers and may kill inner shaded branches and branches weakened by injuries. Cutting out affected branches and stimulating vigorous growth of the trees by feeding and watering them should overcome this disease.

Fig. 40.—*Verticillium* may cause foliage wilt on only a few or on all branches of an affected tree. However, affected trees may recover and not wilt again in succeeding years. This catalpa tree, which wilted in 1940, recovered from the disease and continued to live for many years.

CHESTNUT

Of the leaf and stem diseases that occur on chestnut trees in Illinois, chestnut blight is the most destructive.

Chestnut Blight.—This disease, also called Endothia canker, is caused by the fungus *Endothia parasitica*. One of the most destructive tree diseases in North America, it has practically eliminated the American chestnut from the eastern United States. Development of chestnut blight is indicated by yellowing and browning of leaves on affected twigs and branches. Dead leaves and burs cling to diseased branches and are conspicuous during the dormant period. Young cankers develop as yellowish-brown, oval to irregular areas on smooth-barked, vigorous-growing young stems (Fig. 41). They appear as brownish, discolored

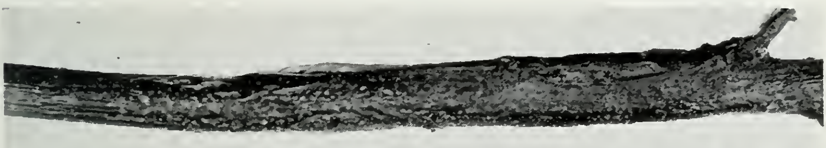


Fig. 41 (*top*).—Cankers produced by chestnut blight appear as yellowish-brown, oval to elongate areas on smooth-barked stems of American chestnut. The canker in this picture is swollen, and cracks have formed in the diseased bark. The small bumps or raised spots in the bark are fruiting bodies of the chestnut blight fungus.

Fig. 42 (*bottom*).—Cankers on Chinese chestnut most often appear on young trees growing in sites that have high humidity and poor circulation of air. These conditions frequently prevail in nursery plantings.

circular to irregular dead areas with slightly depressed or raised margins on slow-growing or old stems with smooth bark. Girdling of stems by these areas results in death of the parts beyond the affected regions. Usually trees die within 3 or 4 years after they have become diseased. No effective control has been developed for chestnut blight. The varieties of chestnut which are resistant to blight are more suitable for ornamental plantings and nut production than for forest trees.

Other Cankers.—Two other canker diseases of chestnut trees have been observed in Illinois. One occurs on American chestnut and is caused by the fungus *Phomopsis castanea.* The other occurs on Chinese chestnut (Fig. 42) and seems to be associated with a fungus belonging to the genus *Fusicoccum*; possibly it is *Fusicoccum castaneum (Cryptodiaporthe castanea).* Affected branches should be cut 1 or 2 feet below any evidence of infection. In nursery and orchard plantings, trees should be spaced to allow for free movement of air.

CRAB APPLE

Crab apple is susceptible to powdery mildew, leaf spot, scab, rust, and canker diseases. Powdery mildew and leaf spot diseases are described in the section "Types of Tree Diseases." Fire blight is the most destructive canker disease of crab apple.

Scab.—This disease of hawthorn and mountain ash, as well as crab apple, is caused by the fungus *Venturia inaequalis.* It appears on both upper and lower surfaces of leaves; frequently it appears first on the lower. It produces olivaceous to sooty or smudgy spots (Fig. 43). On young leaves, diseased areas frequently appear as radiating spots with feathery edges. On older leaves, the diseased areas appear as definite spots with continuous, well-defined margins. In time, the leaf tissues in each spot on the upper side of a leaf thicken and bulge upward until the spot resembles a scab; the tissues on the lower side become depressed and cuplike in appearance. The disease may produce similar spots on blossoms and fruit. On fruit, the spots enlarge and become at first black. Later they become brown, with black margins, and corky.

Heavy scab infections may cause leaves to become curled, distorted, and dwarfed. Leaf stems or petioles that become infected show elongate lesions similar in color to the spots or lesions on leaves. A leaf with several of these lesions on its petiole is likely to turn yellow and drop. Extensive petiole infection may

Fig. 43.—Apple scab develops as small to large olivaceous to sooty spots on leaves. Small young spots are evident on the lower center leaf. Large radiating spots with feathery margins are evident on the upper center leaf. Large definite spots with well-defined margins are evident on the remaining leaves. The lower right leaf has turned yellow because of several elongate lesions on its petiole.

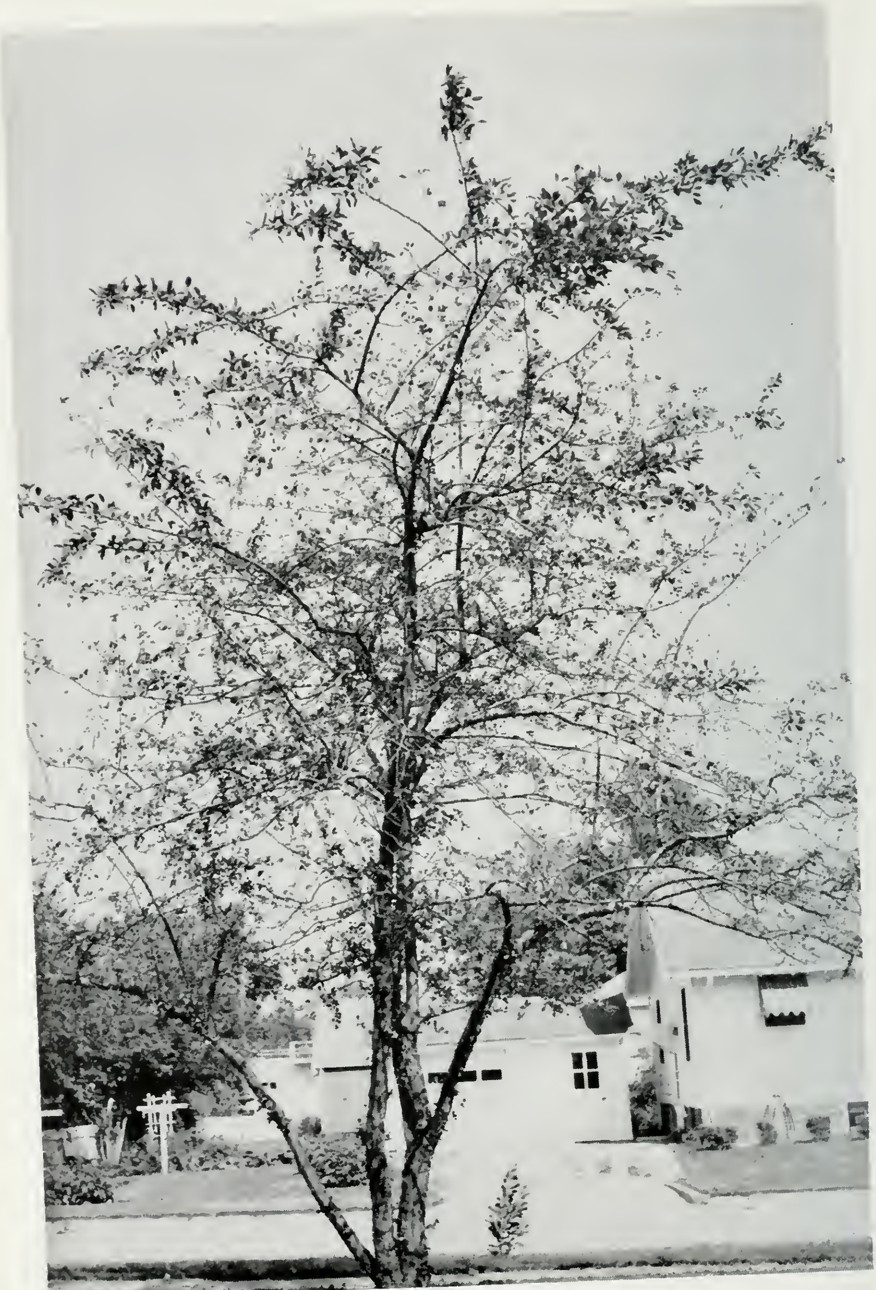


Fig. 44.—Severe defoliation of this crab apple is typical of trees affected by extensive petiole lesions produced by the scab fungus.

cause abundant premature defoliation (Fig. 44). Two to four applications of organic mercury or dodine (Table 1) at 2-week intervals should control scab. The first application should be made as the buds are opening. Apple scab spreads most rapidly during cool, wet weather.

Rust.—Cedar-apple rust (Fig. 45), caused by the fungus *Gymnosporangium juniperi-virginianae*, and other rust diseases

Fig. 45.—On crab apple, cedar-apple rust produces raised, orange spots, which may have dark brown centers. Severely affected leaves are distorted.

of crab apple are described in the section on juniper. Spraying for control of these leaf diseases on valuable specimen plants may be desirable. The sprays recommended are ferbam or thiram (Table 1). Four or five sprays applied at 7- to 10-day intervals are recommended. The first spray should be applied as the buds are opening.

Fire Blight.—This stem disease (Fig. 63), caused by the bacterium *Erwinia amylovora*, is described in the section on mountain ash.

ELM

Elms are subject to many diseases, some of which are among the most destructive of the tree diseases in the United States.

Dutch Elm Disease.—This vascular disease, caused by the fungus *Ceratocystis ulmi*, in 1962 was known to occur in 29 states, the District of Columbia, and three provinces of Canada.

First reported in Illinois in 1950, it had spread to all 102 counties of the state by 1959. A detailed description of the disease and suggestions for its control are given in an Illinois Natural History Survey pamphlet entitled "Dutch Elm Disease in Illinois."

Fig. 46.—Foliage on elms that die rapidly from phloem necrosis turns brown and much of it remains attached to the branches.

Phloem Necrosis.—Phloem necrosis, caused by a virus, is a widespread and destructive vascular disease of American elm, including the Augustine ascending, Moline, vase, and holly-leaf varieties. The virus can infect the winged elm. In 1963 phloem necrosis was known to occur in 15 states; it was present in the southern two-thirds of Illinois and in a few isolated places in the northern third of the state.

Earliest visible symptoms of phloem necrosis appear usually as drooping or curling of leaves, followed by yellowing and browning of leaves, and finally by defoliation of the affected tree. Most elms that show these leaf symptoms in June and July die in a single growing season. On elms which die within 2 or 3 weeks, the leaves do not droop and turn yellow, but wilt rapidly and turn brown; many remain attached to the branches

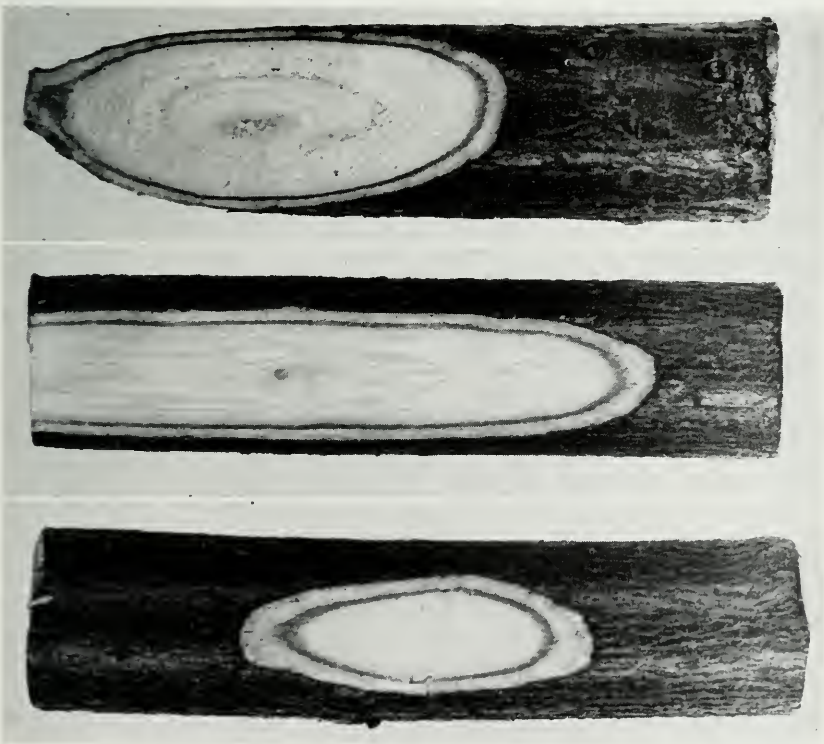


Fig. 47.—The butterscotch color produced in elms affected with phloem necrosis is present in the thin layer of inner bark which is in contact with the wood. When a chip of bark and wood is removed from a diseased elm stem, the butterscotch color appears as a ring where the inner bark is in contact with the underlying wood.

(Fig. 46). Many elms which show leaf symptoms after early August live over winter, produce a sparse crop of leaves the next spring, and die in late June or July. Since these leaf symptoms frequently can be confused with those caused by other elm dis-

Fig. 48.—High-powered mist blowers may be used to obtain adequate coverage of large elms with methoxychlor or DDT for protection against the insect that carries the phloem necrosis virus. Thorough spraying of foliage and crotches of young shoots is very important.

eases, field diagnosis of phloem necrosis is based on the color and odor of the inner bark. In an affected tree, the thin layer of inner bark in contact with the sapwood, especially that at the base of the trunk and in the buttress roots, becomes yellow to butterscotch in color (Fig. 47). Occasionally, dark brown to black flecks are evident in the butterscotch-colored bark. The butterscotch color can be detected only in freshly cut samples of bark, since the inner bark from both diseased and healthy trees turns brown within a few minutes after being exposed to air. The odor of wintergreen emanates from the butterscotch-colored bark of trees affected with phloem necrosis.

Healthy elms may be protected from infection by spraying with DDT or methoxychlor (Table 1) to control the leafhopper which carries the phloem necrosis virus from diseased to healthy trees. Trees should be sprayed twice during the growing season to obtain maximum protection. The first spray should be applied as soon as the spring leaf crop is fully mature, usually during June in Illinois. The second spray should be applied immediately after the midsummer or second growth of elm leaves has occurred, usually after July 15 in Illinois. Each spray should contain 6 per cent insecticide if applied by a mist blower (Fig. 48) or 1 per cent insecticide if applied by a hydraulic sprayer (Fig. 49). Either methoxychlor or DDT is effective against leafhoppers. DDT has certain disadvantages. It is hazardous to birds (page 27), and its use may result in increased populations of harmful mites and insects.

The effectiveness of spraying to prevent the spread of phloem necrosis will not be known for a year after the spray program has been started, as trees are infected with the virus a year or more before they show the disease. No tree already infected with the virus when the sprays are applied will be benefited by the sprays, which protect against infection only during the year or years in which they are applied. For continuous protection, trees must be sprayed each year. Success in preventing phloem necrosis depends on spraying with such thoroughness that no leafhopper bred in a diseased tree is left alive long enough to feed on a healthy tree.

In areas where both phloem necrosis and Dutch elm disease occur, healthy elms may receive protection from the elm leafhopper and the European elm bark beetle by being sprayed three times each year. The first spray is a dormant spray recommended for Dutch elm disease control; the second and third sprays are the two summer sprays recommended for phloem necrosis control (Table 1). Sanitation (the removal and burning of all weakened, dying, and recently killed elm material) is exceedingly important where both diseases occur, because elms killed by phloem necrosis as well as by Dutch elm disease provide excellent breeding places for the smaller European elm bark beetles that carry Dutch elm disease fungus from diseased to healthy trees.

Fig. 49.—Hydraulic sprayers used in spraying elms with methoxychlor or DDT for control of the insect that spreads phloem necrosis must have sufficient power to give thorough coverage of all parts of trees. Drenching that results in excessive run-off should be avoided.

Wetwood.—This vascular disease is caused by the bacterium *Erwinia nimipressuralis*. It occurs in many genera of trees, including apple, birch, elm, fir, hemlock, hickory, linden, maple, mulberry, oak, pine, poplar, redbud, sycamore, tulip tree, and willow. It is more widespread and causes more injury in elms, especially Asiatic elms, than in any other trees. A detailed description of this disease is given in an Illinois Natural History Survey circular, "The Wetwood Disease of Elm."

Verticillium Wilt.—This vascular disease, caused by the fungus *Verticillium albo-atrum*, is described in the section on maple.

Dothiorella Wilt.—The fungus *Dothiorella ulmi*, which causes this vascular disease, produces curling, yellowing, and wilting of

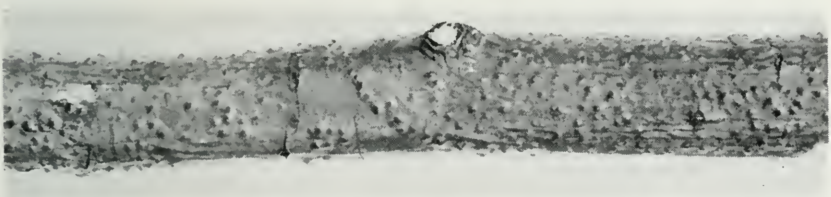


Fig. 50.—Soon after Dothiorella cankers of elm are formed, fruiting bodies of the fungus appear as black, raised pustules in the dead bark. Under moist conditions, spores of the fungus ooze out of the pustules and are deposited on the surface of the bark.

leaves, followed by defoliation, development of cankers on branches, and dieback of affected branches. Diseased bark turns reddish brown and becomes shrunken. In time, black raised pustules of the fungus appear in the diseased bark (Fig. 50). Brown streaks produced in the young sapwood of wilting branches may be confused with those caused by Dutch elm disease or Verticillium wilt.

Dothiorella wilt can be controlled in its early stages if all diseased branches are cut off a foot or more below any evidence of brown streaking in the sapwood. Trees in low vigor should be fed. Spraying to prevent insect injury, as by spring canker worm, is important in preventing infections, especially in nursery plantings, since the fungus enters through wounds.

HACKBERRY

Hackberry is affected by a disfiguring stem disease called witches'-broom.

Witches'-Broom.—This disease, which produces broomlike growths on branches (Fig. 25, 51), is common on hackberry in Illinois. The cause of witches'-broom is not definitely known. However, a powdery mildew fungus, *Sphaerotheca phytoptophyla*, and a gall mite in the genus *Eriophyes* are usually associated with the disease on hackberry. In a hackberry affected with witches'-broom, the buds swell and open wider than is normal for them. Frequently the bud scales become distorted and

Fig. 51.—On hackberry, witches'-brooms, composed of numerous twigs arising from localized areas on branches, are conspicuous when the trees are without foliage in the dormant season.

enlarged. Shoots from the affected buds usually become dwarfed and grow in clusters (Fig. 51). The twigs in each cluster are short and stubby, and the diseased leader fails to develop fully. An open type of broom is formed when a healthy leader has numerous short, stubby twigs produced around its base.

Witches'-broom is more common and widespread on American hackberry than on Chinese or Mississippi hackberry.

There is no effective control for this disease; however, if the brooms are objectionable to the owner of an affected tree, they can be removed by pruning, as described in the section "Pruning." Feeding the tree to stimulate vigorous growth may be desirable; this is described under "Feeding."

HAWTHORN

The three most destructive diseases of hawthorn in Illinois are leaf blight, rust, and fire blight. (Fig. 52, 57, 59, 63).

Rust.—Three fungi, *Gymnosporangium globosum* (cedar-hawthorn rust), *G. juniperi-virginianae* (cedar-apple rust), and *G. clavipes* (cedar-quince rust), cause rust on hawthorns. Of the three rusts, cedar-hawthorn rust is most destructive to hawthorn. These rust diseases are described under juniper. Hawthorns can be protected from these rusts by ferbam or thiram sprays (Table 1). The first spray should be applied in the spring as soon as spore-horns begin to protrude on the cedar-apple galls.

Fire Blight.—This bacterial stem disease, caused by *Erwinia amylovora,* is described in the section on mountain ash.

Leaf Blight.—The fungus *Fabraea maculata* causes a serious leaf blight of hawthorn, especially English hawthorn and Paul's scarlet thorn. It also affects apple, chokeberry, cotoneaster, Japanese quince, medlar, mountain ash, *Photinia,* and serviceberry. Affected leaves (Fig. 52) first show small, angular, reddish-brown spots with irregular or radiating margins on their upper surfaces during the early part of the growing season. These spots enlarge and some of them may coalesce to form large, irregular diseased areas. Severely affected leaves fall prematurely; extensive defoliation occurs when the disease is serious. A small, black, raised, pimple-like spot, fruiting body of the fungus, develops in the center of each diseased area. Spores produced in the fruiting bodies cause additional infection during the growing season.

The raking and burning of fallen leaves will help to control leaf blight. Spotting of leaves can be prevented by spraying with

Fig. 52.—Leaf blight of hawthorn is conspicuous as angular, reddish-brown diseased areas with irregular margins on the upper surfaces of leaves.

cycloheximide or dodine (Table 1). One application of cycloheximide in mid-June or two or three applications of dodine at 2-week intervals, with the first application in mid-June, will control leaf blight.

JUNIPER

Several species of juniper, especially red cedar, are affected by rust diseases, including cedar-apple rust, cedar-hawthorn rust, and cedar-quince rust.

Cedar-Apple Rust.—This disease is caused by the fungus *Gymnosporangium juniperi-virginianae.* It has juniper and apple or crab apple as alternate hosts. On juniper it affects twigs and leaves, especially awl-shaped leaves. It stimulates the infected tissue to form galls, which become visible on a juniper first as small, deep red, smooth, globular growths in the axils of leaves in June of the first spring after infection. These galls enlarge until they become mature the second spring after infection, when they may measure up to 2 inches in diameter.

The mature galls, called cedar apples, are greenish-brown, globular to irregular-shaped, and corky (Fig. 53). As the galls grow, a series of small, circular, pitlike depressions, each with a small pimple-like protuberance in the center, forms on their surfaces. The gelatinous, finger-like, orange spore-horns which protrude from the surfaces of the galls arise from the circular depressions. These spore-horns, one to over a hundred per gall, are

Fig. 53.—Cedar-apple rust on juniper is conspicuous because of the corky, chocolate-brown galls it produces on twigs. A mature gall is called a cedar apple. Spore-horns develop in the depressions of the gall.

each one-fourth to one-half inch long and about one-eighth inch in diameter. They swell during periods of rainy weather in April and May and elongate until they are approximately 2 inches in length (Fig. 54). In dry periods following rainy weather, they contract and appear as thin, wrinkled threads (Fig. 55). In late May or June, they become dry and brittle, and finally drop off the galls. The galls dry, shrivel, and turn black. The shriveled and dried galls do not produce spore-horns in succeeding years, although they may remain attached to the juniper.

On apple and crab apple, cedar-apple rust infects leaves and fruit; however, it is not especially noticeable on fruit of crab apple. The rust appears on leaves in May, first as very small, pale yellow spots visible only on the upper surfaces. These spots become orange and raised as they enlarge. By the time they are about one-eighth inch in diameter, orange-colored drops of exudate appear near their centers. Later, because of the yellowish

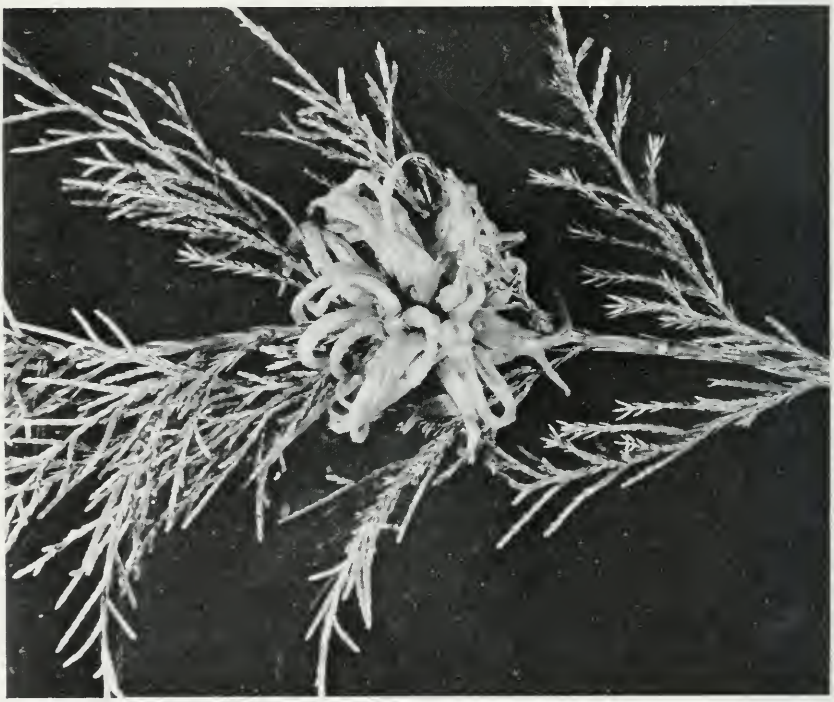


Fig. 54.—During rainy weather in April and May, each mature gall of the cedar-apple rust is covered with numerous gelatinous, finger-like, orange-colored spore-horns, which protrude from the gall.

Fig. 55.—In dry weather, the spore-horns of the mature gall of the cedar-apple rust contract and appear as wrinkled threads.

discoloration of the tissue, these spots become visible on the under surfaces of leaves. At this time, black dots appear on the upper surfaces of the spots. Mature spots, about three-eighths inch in diameter on the under surfaces of leaves, are yellowish-orange and frequently bordered by a red band or a chlorotic (yellow) halo. The tissues in these spots become thickened, and in July and August a number of raised areas or protuberances appear. Later these raised areas develop into cylindrical tubes, which split into segments at their distal ends. These split ends curl outward and backward to expose light brown spores, which are the spores that infect junipers.

Since cedar-apple rust requires juniper and apple or crab apple as alternate hosts, these hosts usually should not be grown close to each other. Junipers planted within a mile of apple or crab apple should, if feasible, be species or varieties resistant to rust. A list of resistant and nonresistant junipers may be obtained from the Illinois Natural History Survey.

In ornamental plantings, where alternate hosts are planted close to each other, protection from rust infection can be obtained by fungicidal sprays. There are two periods when junipers may be sprayed for control of rust. One period is in April or early May, when the orange spore-horns appear on the cedar galls or cedar apples. The other is in July or August, when spores produced on diseased leaves of apple or crab apple are carried to junipers. Cycloheximide (Table 1) applied during the first period, after the spore-horns have appeared and before they become gelatinous, will kill the horns and prevent spore production. Ferbam (Table 1) applied during the second period will protect junipers from spores produced on the foliage of apple or crab apple.

Cedar-Hawthorn Rust.—This disease, caused by the fungus *Gymnosporangium globosum*, produces galls on juniper and leaf rust on apple, crab apple, hawthorn, mountain ash, pear, and serviceberry. It does not produce visible symptoms on the fruit. The galls on juniper are small, reddish-brown, and spherical to irregular in shape but similar in texture to the galls produced by cedar-apple rust. The galls of the cedar-hawthorn rust, most of them less than an inch in diameter, usually originate on young stems, but they may originate on leaves. They persist and produce spores for 3 to 5 years. Only a few brown, wedge-shaped, spore-horns are produced on each gall. During rainy periods, they expand into orange-colored, gelatinous, tongue-shaped structures (Fig. 56). Spores produced on these spore-horns in April and May cause leaf rust on hawthorn and other deciduous hosts. On hawthorn, the disease appears as yellow to orange-colored spots on the upper surfaces of the leaves and as raised orange to brown spots, with tubelike appendages in the centers, on the under surfaces (Fig. 57). These tubelike growths do not split open and curl outward and backward as do the cylindrical tubes produced by cedar-apple rust. If, in late summer, the spores produced in the tubelike growths from the spots on hawthorn leaves are carried by wind to leaves of juniper, they produce brown galls on the juniper.

Because this rust requires both juniper and hawthorn or other pomaceous hosts in its life cycle, the fungus cannot perpetuate itself if the hosts are separated by distances greater than the distance spores are carried by wind. Adequate protection usually is given by distances of a mile or more. Whenever possible, species or varieties of juniper resistant to rust should be planted. A list of these may be obtained from the Illinois Natural History Survey. Spraying as recommended for cedar-apple rust will control cedar-hawthorn rust.

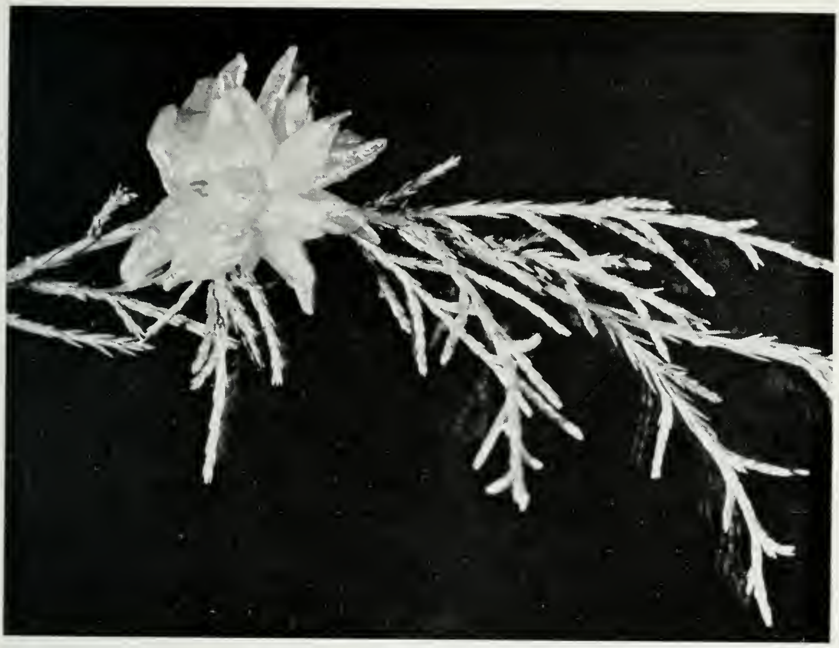


Fig. 56.—The gall of the cedar-hawthorn rust has orange-colored, tonguelike, gelatinous spore-horns.

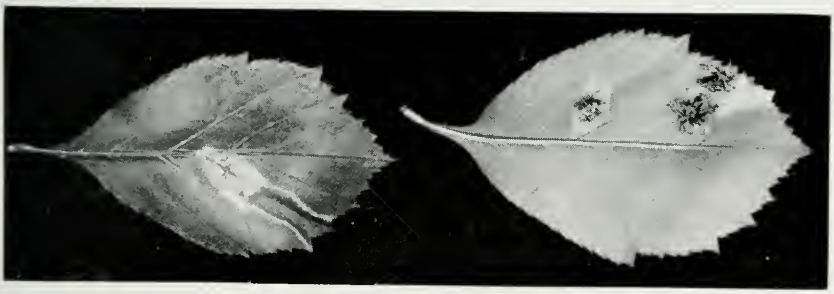


Fig. 57.—Cedar-hawthorn rust produces yellow- to orange-colored, depressed spots on the upper surface of a hawthorn leaf (left), and raised, orange to brown spots, covered with short hairlike appendages, on the under surface (right).

Cedar-Quince Rust.—This fungus disease is caused by *Gymnosporangium clavipes.* It occurs on *Juniperus communis, J. sibirica,* and *J. virginiana.* It produces swollen, elongated, spindle-shaped swellings or galls on branches of juniper. The fungus is perennial in these galls, which enlarge each year. It may be active and produce spores annually for as long as 20 years. A stem and fruit disease, it has apple, chokeberry, crab apple, hawthorn, dwarf Japanese quince, mountain ash, pear, shadbush, or quince as an alternate host. In rainy periods of April and May, orange,

Fig. 58.—Cedar-quince rust produces elongate, swollen cankers on branches of juniper. During rainy periods in April and May, orange-colored, gelatinous masses of fungus spores break through the cankerous bark.

gelatinous masses of spores break through the rough diseased bark of the galls on juniper (Fig. 58). These spores infect young stems and fruit of quince, hawthorn, and other pomaceous hosts. They produce long, slender, cream to white, tubelike structures on twigs and fruit (Fig. 59). Diseased twigs are swollen and deformed. Diseased fruits are deformed and stunted. Bright orange spores from the tubelike structures on twigs and fruit reinfect junipers in late summer. Spraying hawthorn and other deciduous hosts as recommended for cedar-hawthorn rust may control cedar-quince (page 55 and Table 1).

Juniper Blight.—This stem disease, caused by the fungus *Phomopsis juniperovora*, occurs most frequently on red cedar. However, it has been found on other species of juniper and on arbor-vitae, cypress, and false-cypress. The fungus invades and kills the bark, and in time cankers form on the diseased stems. As the cankers enlarge, the affected stems die and the needles turn brown. Young trees that are affected may die. All diseased twigs and branches should be removed and burned. In nursery

Fig. 59.—Fruits of hawthorn affected with cedar-quince rust may be deformed in shape, dwarfed in size, and have orange to cream tubelike structures projecting from their surfaces.

plantings, all affected plants should be destroyed. When available, resistant varieties such as Hill juniper, Keteleer red cedar, and spiny Greek juniper should be used. Spraying with organic mercury or copper sulfate and hydrated lime (Table 1) may prevent infection. Five sprays applied at 10-day intervals are recommended. The first application should be made as soon as shoot growth starts in the spring.

LINDEN

Linden is relatively free of diseases; however, Verticillium wilt affects an occasional tree, and some affected trees die.

Verticillium Wilt.—This vascular disease is caused by the fungus *Verticillium albo-atrum*. In linden, it causes leaf and branch wilt, which are accompanied by the production of brown streaks in the young sapwood of affected branches. These streaks are similar, except in color, to the green streaks that the disease produces in maple. General symptoms and control measures are those given for maple.

MAPLE

Most species of maple grown in Illinois are subject to leaf, stem, and vascular diseases.

Anthracnose.—Anthracnose or leaf blight, caused by the fungus *Gloeosporium apocryptum*, develops in maple as small to large, circular to irregular or indefinite, light brown areas of dead tissues (Fig. 60). As the diseased areas of a leaf enlarge, they may merge with one another until the entire leaf is killed. Severely affected leaves may drop prematurely. However, leaves that have only limited diseased areas may appear as leaves affected with scorch, a noninfectious disease. Anthracnose may appear from late May to early August. Trees affected by this disease for a single year usually are not damaged sufficiently to require treatment. However, trees affected for several successive

Fig. 60.—The anthracnose fungus in maple kills large areas of leaves or occasionally entire leaves.

years may need feeding to stimulate vigorous growth and spraying with organic mercury or copper fungicide to prevent infection (Table 1). Two applications of spray at 10- to 14-day intervals should give effective control. The first spray should be applied when the leaves are about half grown.

Tar Spot.—Soft maple is most frequently affected by this leaf disease, caused by the fungus *Rhytisma acerinum*. Hard maple and red maple are affected only occasionally. The disease appears first as yellowish-green diseased areas on the upper sur-

Fig. 61.—Tar spot of soft maple is conspicuous because of the black, glossy, raised, tarlike spots produced on the upper surfaces of affected leaves.

faces of leaves. These areas, which are oval to irregular in shape, enlarge and become tarlike, thickened, and raised (Fig. 61). The fungus lives over winter in the tarlike spots on fallen leaves and produces spores which, when released during May and June, infect the new crop of young leaves. Tar spot can be controlled if infected leaves are raked and burned in the fall, and the new crop of leaves the following spring are sprayed with an organic mercury or copper fungicide (Table 1). One spray should be applied in early May, and, in unusually wet seasons, a second spray should be applied 3 weeks after the first.

Scorch.—Foliage scorch is a common leaf disease on Norway maple and hard maple during June, July, and August. This disease (Fig. 14) is described in the section "Leaf Diseases." Although it occurs on many maples each year, it does not cause affected trees to die.

Canker and Dieback.—Canker and dieback of twigs and branches on maples have been associated with several fungi in Illinois: *Steganosporium piriforme* on hard maple and Norway maple, *Nectria cinnabarina* on sycamore maple, and *Sphaeropsis negundinis, Leptothyrium maximum,* and *Phacidium negundinis* on box elder. These fungi attack weakened trees and kill twigs and small branches. Occasionally they develop on large dying branches. Affected trees should be given plant food to stimulate growth, and all affected branches should be removed.

Verticillium Wilt.—This wilt, caused by *Verticillium albo-atrum*, is known to affect 16 species of maple in the United States. Other trees affected by this disease include almond, ash, black locust, catalpa, elm, goldenrain tree, linden, magnolia, pagoda tree, redbud, Spanish chestnut, tulip tree, tupelo, and yellow-wood.

Foliage of trees affected by this disease may wilt at any time during the growing season. However, on most affected trees, the foliage wilts in late June or in July or August. Wilt may occur on only a few branches, on whole sections, or on all branches of a tree (Fig. 40) ; in the last case, the tree usually dies very soon. Some trees that show a limited amount of wilt may recover and not show wilt in succeeding years. In maple, *Verticillium* produces fine green streaks in the young sapwood of wilting branches, especially in sapwood of the current season (Fig. 62). In other kinds of trees, *Verticillium* produces brown to yellowish-brown streaks in the young sapwood of wilting branches. Since the fungus can live in the soil and invade the trees through the roots, the streaks in the sapwood spread from the roots up through the trunks and into the branches. The basal portions of branches showing wilt should be examined for the streaks, since these streaks may not extend to the tips of affected branches.

Affected trees should be given plant food to stimulate vigorous growth, as described in the section "Feeding." All dead branches or dead wood on branches showing wilt should be removed. However, it is advisable not to remove live branches or twigs on which the leaves are wilting or have recently wilted. Many branches that show wilt may not die but may produce a new crop of leaves 3 or 4 weeks after wilt has occurred or by the following spring. Pruning will not eliminate fungus that is present in the trunks and roots of affected trees.

Fig. 62.—Maples affected with Verticillium wilt have green discoloration in the young sapwood, especially in the current-season wood. This green discoloration frequently appears as fine streaks. Occasionally it may appear as solid bands of green in individual wood rings. In trees of other kinds, the discoloration is brown.

MOUNTAIN ASH

Leaves of mountain ash are occasionally affected with a fungus disease called scab. This disease is described in the section on crab apple. The most destructive disease of mountain ash in Illinois is fire blight.

Fire Blight.—This bacterial disease, caused by *Erwinia amylovora,* produces branch and trunk cankers (Fig. 63), twig blight or dieback, and blight of leaves, blossoms, and fruit of mountain ash. It affects other ornamental plants, also: cotoneaster, crab apple, fire thorn, Japanese flowering quince, rose, serviceberry, and spirea.

Leaves and blossoms of a mountain ash affected with fire blight suddenly wilt and turn brown to black, as if scorched by fire. Affected twigs die. The disease may spread from twigs to branches and produce extensive cankers. Cankers usually are bounded by cracks between the dead and living bark. The dead bark usually turns reddish brown. Cankers that girdle the trunk may cause sudden leaf blight, followed by death of the tree.

Fig. 63.—Fire blight cankers are usually conspicuous because of the rough, scaly, depressed appearance of the diseased bark and the formation of fissures or cracks between the living and diseased bark. The canker shown in this picture is on crab apple.

Plants that have large cankers or diseased areas on their stems should be cut and burned. Those that show the disease on only scattered branches need not be destroyed, but the diseased branches should be removed and burned. Removal of all visible infection in a branch is possible if this branch is cut off 18 inches or more below the base of the external diseased area. Tools used in removing a diseased branch should be treated with a disinfectant to prevent spread of the bacteria to other branches or trees. All large wounds should be painted with a wound dressing, as described under "Wound Treatment." Blossom blight and twig blight infection can be prevented or reduced by applying one or two sprays of copper sulfate, 4 pounds in 100 gallons of water, at 2-week intervals before buds open. Spread of twig blight during prolonged wet springs can be prevented by spraying with streptomycin as recommended by the manufacturer. The first spray should be applied as soon as twig blight appears and additional sprays at 7-day intervals until July 15.

OAK

The oak is subject to several destructive diseases. Oak wilt is the most destructive disease of oak in Illinois.

Anthracnose.—This leaf disease, as caused by the fungus *Gnomonia veneta*, affects both white oak and sycamore. On white oak, anthracnose develops as irregular brown diseased areas along the midribs and lateral veins of leaves (Fig. 64). In some cases, the blades of most leaves of affected trees are killed, especially the blades of leaves on the lower branches. Dark brown fruiting bodies (pustules) of the fungus appear on the diseased areas of the leaves, especially on the midribs and veins. These raised pustules or bumps can be seen with a hand lens and occasionally with the naked eye. The fungus may spread from the leaves into the twigs, where it produces cankers or causes twig dieback.

Control for anthracnose in oak includes burning of diseased leaves and twigs and spraying of affected trees. Fallen leaves and twigs should be gathered and burned in the autumn. Whenever possible, diseased twigs should be removed and burned. Spraying with organic mercury or Bordeaux mixture (copper sulfate and hydrated lime) is recommended for the prevention of leaf infection in the spring (Table 1). The first spray should be applied when the leaves are about half grown. In wet springs, a second spray should be applied 14 days later. Oak trees that have been severely weakened by anthracnose over a period of years should be given plant food to stimulate growth, as described in the section "Feeding."

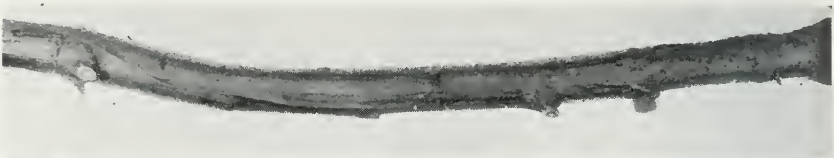
Leaf Blister.—Leaf blister or leaf curl, caused by the fungus *Taphrina caerulescens*, affects the various species of oak. Red oak is especially susceptible. Usually the disease appears only

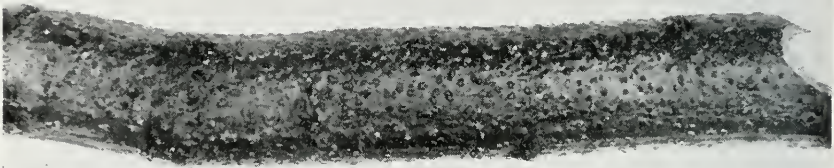
Fig. 64.—Anthracnose of white oak kills irregular areas of tissue along midribs and veins. The light brown killed areas contrast sharply with the green color of the adjacent living tissues.

during cool, wet springs. Affected leaves show circular, raised, wrinkled, yellowish areas on their upper surfaces; the diseased areas appear as depressions on the lower surfaces of the leaves. Leaf blister seldom causes serious damage. It can be controlled by a spray of lime sulfur or of Bordeaux mixture (copper sulfate and hydrated lime), page 26. One spray applied before the buds open in the spring is recommended.

Rust.—Leaf rust, caused by the fungus *Cronartium quercuum*, occurs infrequently on oak in Illinois. It produces small yellowish spots with brown, bristle-like tendrils on the undersides of leaves. Usually it causes insufficient damage on oak to warrant control treatment. Several species of pine are the alternate hosts of this rust.

Smooth Patch.—Smooth patch, sometimes called smooth bark or white patch, is a fungus disease of the outer bark of white oak. It causes the outer rough bark to slough and leaves irregular to circular, smooth, light gray, depressed areas in the





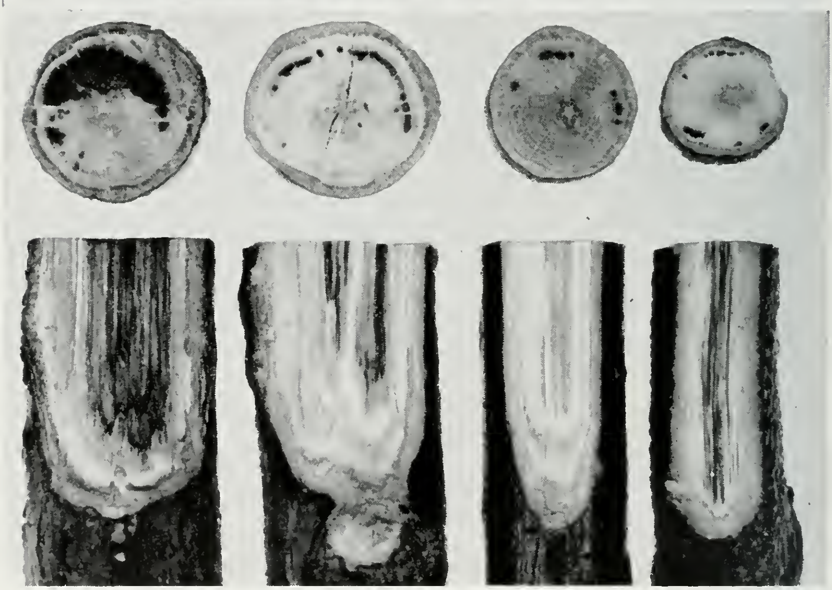


Fig. 65 (*top*).—Dothiorella cankers on oak develop as oval to elongate, dark brown, depressed areas in the bark of affected branches. A conspicuous ridge is visible between the diseased bark on the top and the living bark on the bottom of the section of branch in this picture.

Fig. 66 (*center*).—Fruiting bodies of the Dothiorella fungus develop as pustules in the dead bark of oak and erupt through irregular openings in the outer bark.

Fig. 67 (*bottom*).—In an oak affected with Dothiorella canker, the sapwood beneath the diseased bark is discolored dark brown to black, and streaks of discoloration extend into the adjacent living wood.

bark on the trunk. These areas vary from a few inches to more than a foot in diameter and occasionally form a band around the trunk. The fungus *Aleurodiscus oakesii* is associated with this disease. It grows in the outer diseased bark and produces very small, cream-colored, cup-shaped, and somewhat leathery, cushion-like fruiting bodies, which appear during winter and spring. Since the fungus is confined to the outer, rough, dead bark, the disease does not retard growth of affected trees.

Dothiorella Canker.—This stem disease, caused by the fungus *Dothiorella quercina*, is the most destructive canker disease of oak in Illinois. It affects twigs, branches, and occasionally the trunks of trees in both the white oak and red oak groups. Cankers develop as dark brown, oval to elongate, sunken areas in the bark (Fig. 65). Frequently, cracks form between the living and dead bark along the margins of the cankers. Soon after the bark has died, fruiting bodies of the fungus develop as pustules in the diseased bark. In time, they erupt through irregular openings in the bark (Fig. 66), and spores (Fig. 2) of the fungus ooze out on the surface of the bark. The young sapwood beneath the diseased bark is dark brown to black and shows streaks of discoloration that extend into the living wood beyond the area of diseased bark (Fig. 67).

Other fungi which may cause canker and dieback, especially of weakened oaks, include species of the following genera: *Bulgaria, Coniothyrium, Coryneum, Cytospora, Diatrype, Fusicoccum, Nummularia, Phoma, Phomopsis, Pyrenochaeta, Sphaeropsis*, and *Strumella*.

Oak Wilt.—This vascular disease, caused by the fungus *Ceratocystis fagacearum*, affects all of the important native oaks in the Midwest (Fig. 68). Also it has been associated with bush chinquapin, Chinese chestnut, European chestnut, and tan-bark oak. It is the most destructive disease in oak woodlots and forest areas in the United States.

Wilt of leaves usually appears first on branches in the upper portion of the crown of an affected tree. The wilt progresses downward and inward until all of the foliage is affected. Leaves on trees in the red oak group become dull or pale green in color, and the margins may curl upward. These symptoms are followed by yellowing or bronzing of the leaf tissues; the discoloration spreads from the margins toward the midribs of affected leaves, which may fall at any stage of wilt. Mature leaves usually remain stiff and fully expanded during the different stages of wilt

Fig. 68.—Red, black, and other oaks in the red oak group, when affected by oak wilt, usually wilt and die over a period of several weeks or during a single growing season. In most cases, wilt of leaves appears first on branches in the upper portion of the crown of the affected tree. The wilt progresses downward and inward until all the foliage is affected. The tree in the center of this picture has many branches without leaves, and leaves on the remaining branches are wilted and dead. Located in Ingersoll Park at Rockford, this tree was the first oak in Illinois from which the oak wilt fungus was obtained. The tree, which died in 1942, showed brown streaking in the current-season wood typical of the oak wilt disease.

and for some time after death. Immature leaves curl, droop, turn dark brown to black, and remain attached to the branches. Leaves on wilting bur oak and white oak usually turn light brown or straw color, curl, and remain attached to the branches.

In trees of the red oak group, brown to black discoloration usually develops in the current-season sapwood of wilting

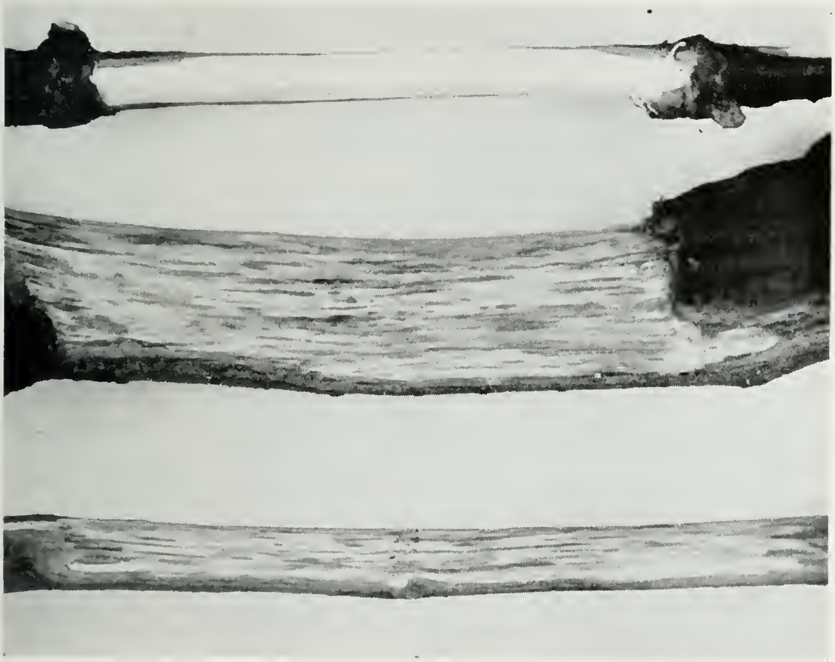


Fig. 69.—In trees of the red oak group that are affected with oak wilt, brown to black streaks develop in the young sapwood of wilting branches. The normal white color of healthy sapwood is shown by the branch piece at top of picture.

branches. This discoloration may appear as streaks or as diffused browning of individual wood rings (Fig. 69). Similar sapwood discoloration has been observed occasionally in wilting bur oak trees.

Affected trees in the red oak group may wilt and die in 4 to 6 weeks, or during a single growing season. Occasionally, large branches of trees infected late in the summer live over winter and produce a few scattered leaves before dying the following spring. Trees of the white oak group usually die slowly over a period of years.

Control of oak wilt in localized areas has been obtained by the poisoning or removing of healthy oaks adjacent to diseased trees or by trenching between diseased and healthy trees. These treatments interrupt an extensive underground system of intergrafted roots (Fig. 70) through which spread of the fungus from tree to tree might take place. Removal of the first wilting

Fig. 70.—The oak wilt fungus can pass from a diseased tree to a healthy tree through grafted roots. Grafting occurs frequently between roots of trees that are within 50 feet of each other, especially trees in the red oak group.

branches in trees of the white oak group may keep the trees healthy for a few years, but these trees are subject to reinfection. Effective control measures to prevent the spread of oak wilt over long distances have not been developed. Squirrels and several kinds of sap-feeding insects are attracted to the mats of the oak wilt fungus which are produced beneath the bark of wilt-killed oaks, and it has been shown experimentally that these animals and insects can carry the oak wilt fungus on their bodies. Removal and destruction of diseased oaks before fungus mats are produced will eliminate this important potential source of fungus inoculum.

Shoestring Root Rot.—Many oak trees that show branch dieback and staghead (frontispiece) are affected with Armillaria or shoestring root rot caused by the fungus *Armillaria mellea.*

Fig. 71.—Fungus strands produced under the bark of oaks affected with shoestring root rot are slender, flattened, dark red, and rootlike in appearance. The shoestrings, or rhizomorphs, that grow in the duff and soil around diseased oak trees are black and round, and they measure about one-sixteenth inch in diameter.

Fig. 72.—The white, fanlike growth of the shoestring fungus produced under the bark of diseased oaks is called a mycelial fan.

This fungus produces two types of growth—slender, flattened, dark red, rootlike strands (Fig. 71) and white mycelial fans (Fig. 72) beneath the bark of infected trees. The rootlike strands or shoestrings which grow in the duff and soil around infected trees are round, black, and about one-sixteenth inch in diameter. Since weakened and injured trees are most susceptible to this disease, maximum protection can be obtained by avoidance of root injuries and by applications of plant food to maintain vigorous growth, as described in the section "Feeding."

PINE

Pine is affected occasionally by needle blight diseases and by a tip blight disease. The white pine blister rust has been known in Illinois since 1946, when it was found in Jo Daviess County.

Needle Blight.—This leaf disease, mainly of Austrian pine, is caused by the fungus *Dothistroma pini*. It appears in late summer as slightly swollen, dark spots or bands on 1-year-old needles. The part of a diseased needle from the swollen area to the tip turns light brown and dies. The swollen areas, produced by growth of the fungus in the needles, do not enlarge during the fall and winter months. However, they begin to enlarge in March. By May they appear as dark brown to black, raised fruiting bodies visible through fissures in the needles (Fig. 73). Spores produced in these fruiting bodies can cause new infections. Affected trees show sparse foliage, since the diseased needles drop prematurely.

Spraying with organic mercury or copper sulfate and hydrated lime during April and early May should control needle blight (Table 1). The first spray should be applied about the middle of April. In wet seasons, a second spray should be applied 3 weeks after the first spray.

Needle Cast.—This leaf disease, caused by several species of fungi of the genus *Lophodermium*, produces reddish-brown spots or elongate areas on affected needles. Fruiting bodies of the associated fungus appear as small, black, oval spots on the diseased portions of needles (Fig. 74). Needle cast seldom causes sufficient damage to warrant control treatment. Spraying with copper sulfate and hydrated lime, as indicated for tip blight (Table 1) has been reported to control needle cast.

Needle Rust.—This fungus disease, mainly of red pine, develops in the spring as cream- to orange-colored, baglike pustules

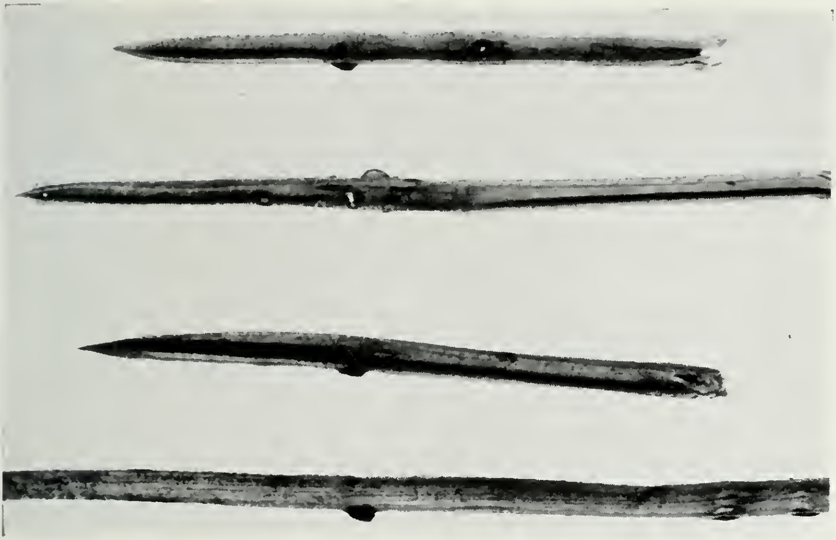


Fig. 73.—Fruiting bodies of the needle blight fungus push out through fissures in diseased needles of Austrian pine. They appear as dark brown to black pustules or bumps.

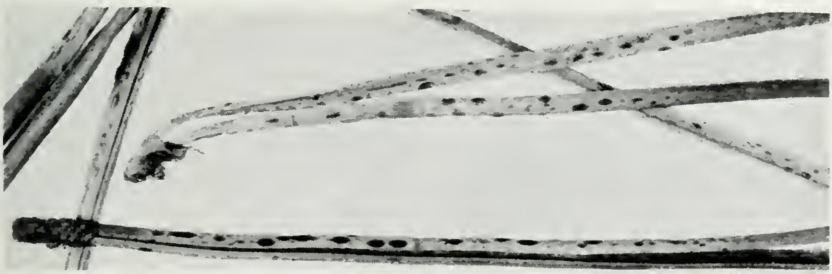


Fig. 74.—Fruiting bodies of the needle cast fungus appear as small, black, oval spots on diseased portions of pine needles.

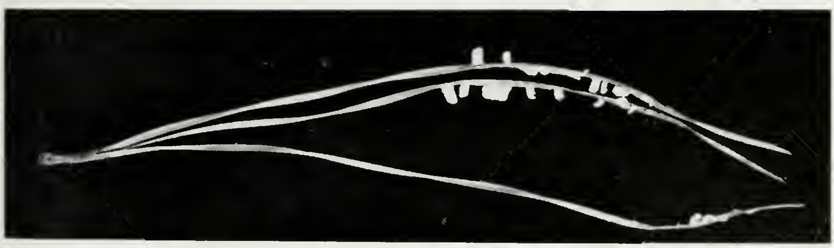


Fig. 75.—Conspicuous cream- to orange-colored, baglike fruiting bodies attached to pine needles affected with rust contain numerous, orange, powder-like spores of the fungus.

on needles (Fig. 75). Of the fungi that cause needle rust, *Coleosporium solidaginis* is most important. Goldenrods and asters are alternate hosts of this fungus. Needle rust may cause defoliation and stunt young pine trees, but it seldom causes much damage on older trees.

Sooty Mold.—A heavy, sooty, threadlike growth or crust may appear on needles of pine (Fig. 76), fir, and other evergreens, and on leaves of elm, linden, maple, tulip tree, and other deciduous trees. This growth, made up entirely of fungus material, may be in isolated patches or it may cover an entire needle or leaf surface. The fungi that cause sooty mold belong to the family Perisporiaceae. They grow as saprophytes on secretions (honeydew) produced by aphids and scale insects. Although sooty mold appears unsightly, it causes little if any noticeable damage to trees. Control of the insects responsible for the secretions will eliminate sooty mold.

White Pine Blister Rust.—This stem disease, caused by the fungus *Cronartium ribicola*, is widespread in the north-central,

Fig. 76.—Sooty mold, which occurs on many kinds of trees, is conspicuous because of the black, threadlike growth or crust produced on the surface of leaves and twigs, as shown on this pine. This disease seldom causes serious damage.

Fig. 77.—The orange to yellow blisters or fruiting bodies of the white pine blister rust fungus are conspicuous during late spring.

northeastern, and northwestern parts of the United States. It is known to occur on white pine in several counties in the northern half of Illinois. The fungus invades and kills the needles. It grows from the needles into the bark of twigs and branches, where it produces swollen, oval cankers. As these cankers enlarge, they girdle and kill infected stems. In late spring, orange to yellow blisters or fruiting bodies of the fungus break through fissures in the diseased bark (Fig. 77). Spores produced in these fruiting bodies infect leaves of currants and gooseberries, plants that serve as alternate hosts. Small orange to yellow pustules are produced on the leaves of these shrubs in summer. The spores produced in these pustules cause new infections on white pines.

A common recommendation for protection of white pines from blister rust is the eradication of all currants and gooseberries within one-half mile of the pines. However, in many situations involving ornamental plantings such eradication may not be feasible. Recently, blister rust was controlled on western white pine by the antibiotic fungicide *Acti-dione BR*. Treatment of diseased trees included removal of dead and dying branches at their points of attachment. The pitch that had accumulated on the surfaces of cankers was removed. Each trunk and branch canker, the surrounding bark area, and branch stubs were then sprayed with *Acti-dione BR*. Detailed information about *Acti-dione* for control of blister rust on pines should be obtained from the manufacturer.

Diplodia Tip Blight.—This stem disease, caused by the fungus *Diplodia pinea*, occurs frequently on Austrian pine, less often on Scotch, red, and mugho pines, and occasionally on Douglas fir and blue spruce. It causes the needles to turn brown and the twig tips to die (Fig. 78). Development of minute, black fruiting bodies of the fungus at the bases of needles that have turned brown and in the bark of twigs that have died differentiates the disease from frost injury and similar twig troubles.

Control of this disease requires first that all affected twigs should be removed and burned. Additional protection may be obtained by sprays of organic mercury or copper sulfate and hydrated lime (Table 1). Three applications of spray are recommended. The first spray should be applied as soon as new shoot

Fig. 78.—Drooping and dying of shoot tips and browning of needles of spruce are typical of Diplodia tip blight.

growth appears, the second when new shoot growth is about half grown, and the third about 2 weeks later. Trees stunted by the disease should be given tree food to stimulate vigorous growth, as described under "Feeding."

POPLAR

Some species of poplar, such as Lombardy and Simon, are frequently attacked by canker diseases and occasionally by rust and crown gall.

Rust.—Larch rust, a leaf disease caused by the fungus *Melampsora medusae*, has poplar and larch as alternate hosts. It occurs occasionally in Illinois. On poplar, it produces yellowish-orange, powdery pustules on the lower surfaces of leaves during the early summer. These pustules change to dark brown or black during late summer and autumn. They may be scattered, or they may be so closely crowded that the entire surface of an affected leaf appears powdery. Leaf rust usually causes insufficient damage on poplar to warrant treatment.

Cytospora Canker.—This stem disease, caused by the fungus *Cytospora chrysosperma*, often kills Lombardy and Simon poplars in Illinois. On young trees, cankers first appear as slightly sunken areas in the smooth bark of branches and trunks. These cankers are circular to oval or irregular in shape (Fig. 79). They gradually enlarge until, frequently, affected stems are girdled and killed. As the cankers enlarge, the diseased bark be-

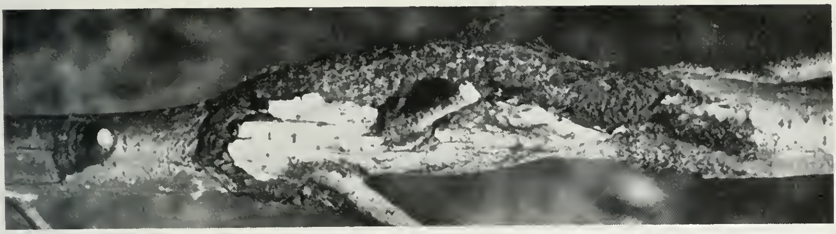


Fig. 79.—Elongate, depressed Cytospora cankers may girdle and kill affected stems of poplar.

comes brown and sunken. The fungus produces fruiting bodies which appear as pustules in the diseased bark. Spores of the fungus are produced in these fruiting bodies and under moist conditions they ooze out in slender, threadlike coils. These spores may be splashed by rain or carried by wind, birds, or insects to other trees.

All dead and dying branches of affected trees should be removed. Trees affected with extensive trunk cankers may be cut and burned, or they may be subjected to careful surgery, followed by the use of a disinfectant, such as denatured alcohol. Surgery may prolong the lives of some severely affected trees. Wounding of healthy trees should be avoided, since the fungus enters trees through wounds. Trees should be given plant food to maintain vigorous growth, as described in the section "Feeding." When it is feasible to do so, the planting of species of poplar most susceptible to this disease, such as Simon and Lombardy, should be avoided.

Dothichiza Canker.—This stem disease, caused by the fungus *Dothichiza populea,* affects many species of poplar; it is most destructive on Lombardy poplar. It produces oval to enlongate sunken cankers on the twigs, branches, and trunks. In time, the diseased bark turns brown and cracks, and the underlying dark brown diseased wood is exposed. Callus tissues which form at the borders of the cankers tend to grow over the surface of the exposed wood. Trunks and branches girdled by cankers die. Young trees usually are killed by the disease. Older trees may not be killed but usually they are disfigured to the extent that they lose their ornamental value. The treatments recommended for trees affected by Cytospora canker usually are effective against this disease.

Crown Gall.—This stem disease as it affects poplar is described in the section on willow.

REDBUD

Redbud is affected occasionally by a canker disease and by a wilt disease. However, these diseases are not necessarily fatal.

Canker.—This stem disease, caused by the fungus *Botryosphaeria ribis chromogena*, has been seen on redbud in several parts of Illinois. It causes cankers on branches (Fig. 80) and occasionally on trunks of affected trees. The cankers are produced during May and appear as inconspicuous, oval, flattened areas. They become elongate and sunken as they enlarge during June. Frequently cracks form between the living and dead bark. After the cankers cease enlarging, callus tissues form along their margins and spread inward over the diseased areas. Small cankers may be covered with callus tissues in a single growing season, while large cankers may not be covered for several growing seasons. Affected branches show sparse foliage, and branches girdled by cankers die.

In most cases, this disease can be controlled by removal of the affected branches and by applications of plant food to stimulate vigorous growth of the affected trees, as described in the section "Feeding." In severe cases, it may be necssary to remove the trees.

Verticillium Wilt.—This vascular disease, caused by the fungus *Verticillium albo-atrum*, occasionally affects redbud and causes partial to complete wilt of branches. Part or all of a wilt-

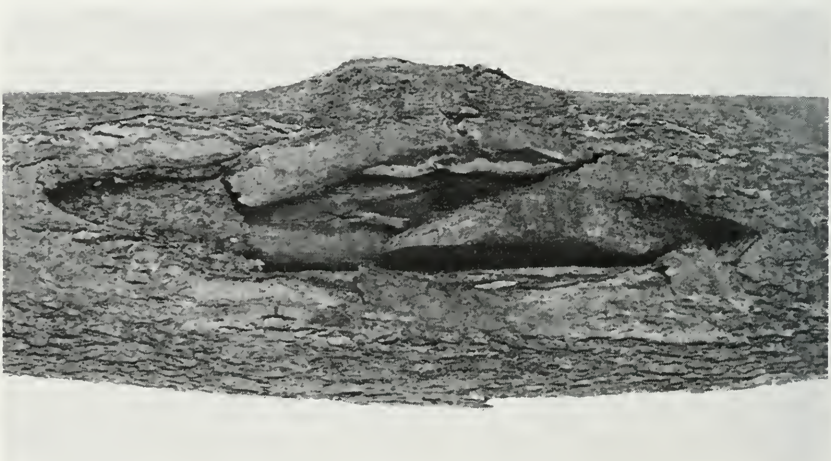


Fig. 80.—Botryosphaeria cankers occur on branches and trunks of redbud in Illinois. This 2-year-old canker on redbud shows cracked and peeling cankerous bark and callus tissue bordering the canker.

ing branch may die, and occasionally wilt-affected trees die. Some trees may recover from this disease and not wilt in succeeding years. Treatment of trees affected with Verticillium wilt is described in the section on maple.

SPRUCE

The most destructive disease of spruce in Illinois is Cytospora canker. Occasionally spruce trees are affected by Diplodia tip blight.

Cytospora Canker.—This stem disease, caused by the fungus *Cytospora kunzei,* appears most frequently on Norway spruce and Colorado blue spruce. Occasionally it attacks Koster's blue spruce and Douglas fir. Browning of needles and dying of the low branches of affected trees are usually the first symptoms of Cytospora canker. As the disease progresses, it spreads to higher branches. In time, affected trees become unsightly and lose their value for ornamental purposes.

The cankers produced are inconspicuous because the affected bark does not noticeably change color or become depressed. Frequently white patches of resin appear on the bark in areas where cankers have formed (Fig. 81). Careful removal of a thin outer layer of bark in the area that separates diseased and healthy tissues will reveal tiny, black, pinhead-like fruiting bodies of the fungus in the diseased bark. These fruiting bodies contain minute spores which can be spread by rain, wind, or pruning tools. The development of trunk cankers may result in girdling and death of affected trees. Cytospora canker, most common on trees over 15 years old, is known to occur on younger trees, also.

Control of Cytospora canker requires that all diseased branches should be cut back to the nearest living laterals or to the trunk of the affected tree. Wound dressing should be applied

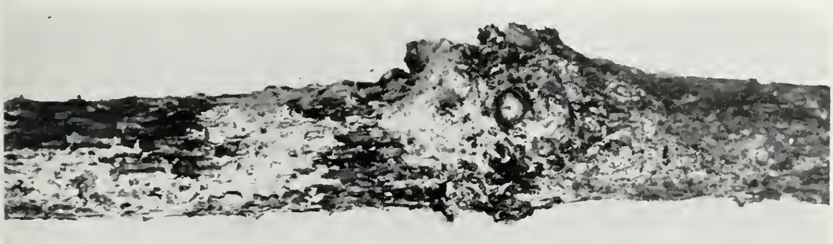


Fig. 81.—The occurrence of Cytospora canker on spruce is usually indicated by conspicuous deposits of resin on the bark. This resin frequently forms as a white incrustation.

to all pruning wounds, as described in the section "Wound Treatment." The bark should not be injured unnecessarily, since the fungus may enter through wounds resulting from injuries. When the branches of affected trees are wet, spores ooze out from cankers onto the surface of the bark. Pruning at this time should be avoided, since spores may be spread by pruning tools. Spraying the low branches and the trunks of affected trees and nearby healthy trees in the spring with organic mercury or copper sulfate and hydrated lime may help to prevent spread of the disease. The spray materials are the same as those for tip blight of spruce (Table 1) ; three or four applications of spray at 2- to 3-week intervals are required. Since, it is believed, weakened trees are susceptible to this disease, feeding to stimulate vigorous

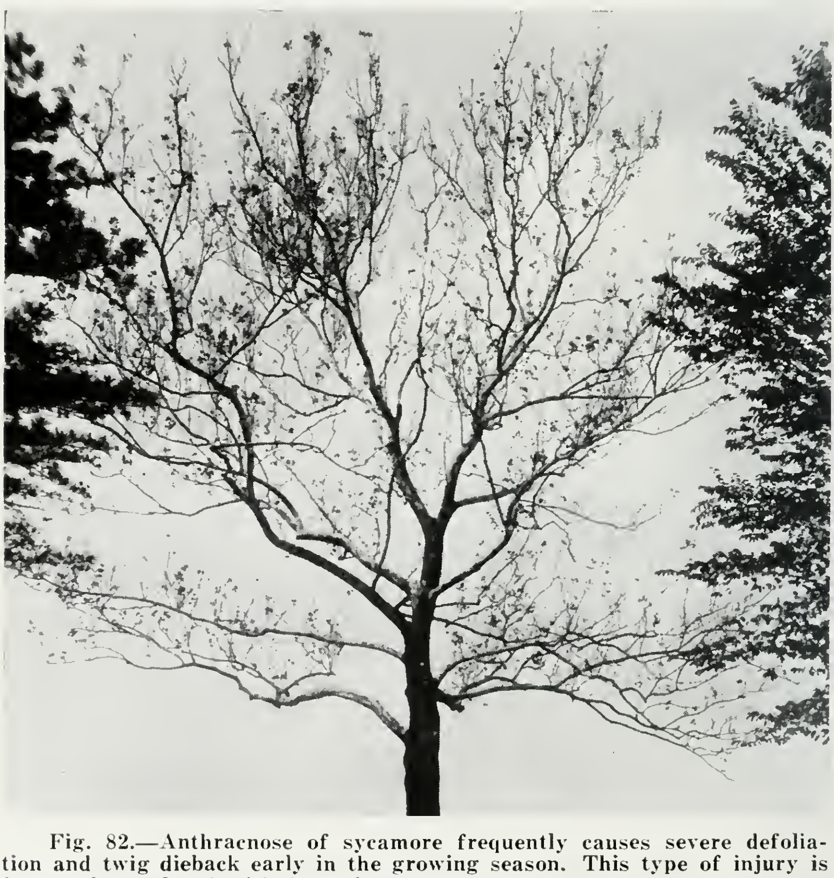


Fig. 82.—Anthracnose of sycamore frequently causes severe defoliation and twig dieback early in the growing season. This type of injury is frequently confused with frost damage.

growth, as described under "Feeding," may help to combat Cytospora canker. Feeding will also stimulate new growth that may fill in vacant areas in the contour of trees on which surgery has been performed.

Diplodia Tip Blight.—This disease of spruce, pine, and Douglas fir is described in the section on pine.

SYCAMORE AND LONDON PLANE TREE

The American sycamore and the London plane tree are planted extensively for shade in some Illinois communities, especially those in which the American elm has been killed by phloem necrosis or Dutch elm disease. Anthracnose causes extensive defoliation and twig dieback in the American sycamore in some years (Fig. 82), but it seldom causes conspicuous damage to the London plane tree. However, the London plane, an English relative of the sycamore and similar in appearance, is susceptible to canker stain, which has killed many trees in some of the eastern states.

Anthracnose.—This leaf and twig disease is known also as twig blight. In oak, as well as sycamore and London plane, anthracnose is caused by the fungus *Gnomonia veneta*. In sycamore, the fungus produces blight in four distinct stages identified as twig blight, bud blight, shoot blight, and leaf blight.

Fig. 83.—Twig blight of sycamore results in killing the tips of 1-year-old branches before leaves appear in the spring.

Twig blight, the first stage, occurs before leaves emerge in the spring and results in killing of the tips of small, 1-year-old twigs (Fig. 83). Small, black fruiting bodies of the fungus soon appear in the bark of the killed twigs. In time, cankers form and affected twigs may be girdled. Repeated annual killing of twigs results in gnarled or brushy branch growth (Fig. 84).

Bud blight, the second stage, occurs as the buds begin to expand in April or early May. Girdling cankers produced by the fungus kill the buds before bud caps begin to break (Fig. 85).

Shoot blight, the third stage, is conspicuous as sudden dying of expanding shoots and young, immature leaves on affected branches (Fig. 86). This blight and death of young leaves is often confused with frost injury.

Leaf blight, the fourth stage, is produced by direct infection of expanding or mature leaves. The infection results from the fungus spores produced on twigs and branch cankers (Fig. 87).

Fig. 84.—Severe twig blight of sycamore for several successive years results in gnarled or brushy branch growth.

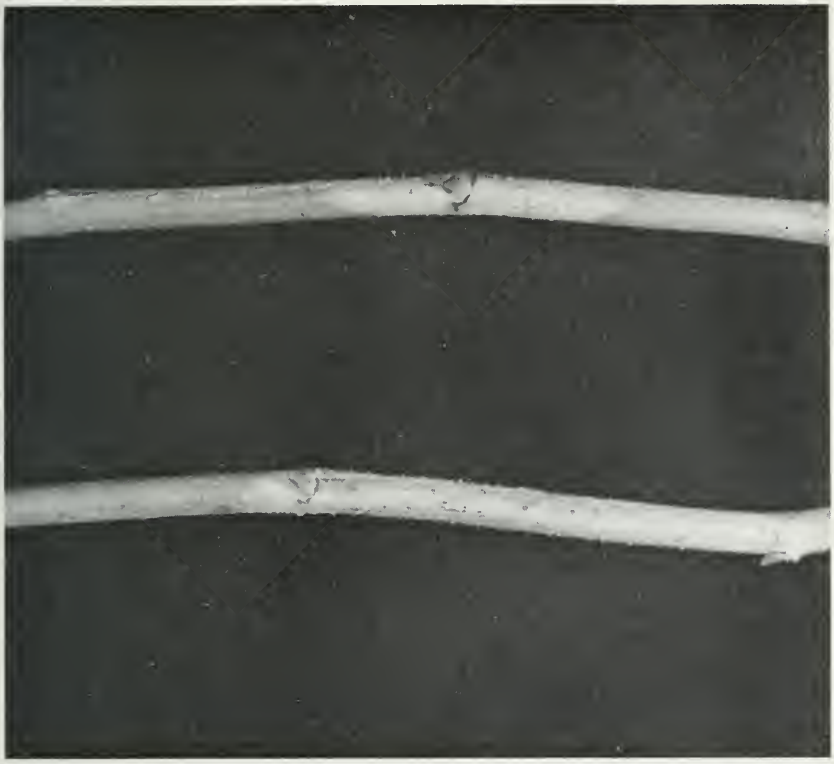


Fig. 85.—Bud blight of sycamore occurs in the spring before leaves appear. Buds are killed by cankers produced in twigs.

Fig. 86.—Shoot blight of sycamore occurs shortly after growth of leaves starts in the spring. It results in the killing of young developing shoots to which affected leaves are attached.

Fig. 87.—The sycamore anthracnose fungus frequently spreads from leaves into twigs and branches and forms cankers on the branches around the bases of the diseased twigs.

The diseased areas on the leaves are small to large, irregular brown areas adjacent to and centering around diseased spots on the midribs and veins (Fig. 88). This type of leaf injury rarely causes conspicuous defoliation. Dark brown fruiting bodies or pustules of the fungus appear on the diseased tissues, especially on the midribs and veins. The pustules can be seen with a hand lens and sometimes with the naked eye. During the summer and fall, the fungus spreads from the diseased areas through the veins, midribs, and petioles into the twigs to which the leaves are attached. It overwinters in the invaded twigs and becomes active the following spring, when it causes twig blight, the first stage described above.

Severity of anthracnose is related to temperatures prevailing during a 2-week period that starts with the first leaf emergence in the spring. Severe shoot blight will occur if the average mean daily temperature during this period is between 50 and 55 degrees F. Shoot blight decreases as the average mean daily temperature increases from 55 to 60 degrees F. Very little if any shoot blight will occur if the average mean daily temperature is above 60 degrees F. Warm periods of a few days with day temperatures above 80 degrees F will prevent extensive fungus growth. A limited amount of fungus growth will result in little or no anthracnose.

Trees severely affected with anthracnose for several successive years may have many branches die. Such affected trees should be given plant food to stimulate growth. One organic mercury spray applied when the buds are swelling and the bud caps begin to break (Fig. 89) will control anthracnose unless cool weather prevails for a period of 2 or more weeks after the spray is applied. During a long cool period, a second spray should be applied 14 days after the first spray. Effective organic mercury sprays include *Puratized Agricultural Spray* and *Coromerc* (Table 1). Similar fungicides are *Phix* and *Tag 331*, which should be used at dosages recommended by the manufacturers.

Fig. 88.—One type of sycamore anthracnose leaf injury appears as small to large, irregular brown areas along the veins and midribs of mature leaves. This type of injury seldom causes serious defoliation.

Fig. 89.—For the prevention of anthracnose, sycamores should be sprayed when the buds are swelling and the bud caps are beginning to break.

Anthracnose causes insufficient injury of London plane trees to justify spraying for control. Control of anthracnose of oak is described in the section on oak.

Canker Stain.—Canker stain, caused by the fungus *Ceratocystis fimbriata* f. *platani,* is a deadly stem disease of London plane trees. Known principally in the eastern and southeastern parts of the United States, it has been reported in Missouri but not in Illinois. However, it could easily spread into the East St. Louis area from St. Louis, Missouri, where it was found in 1947.

This disease has been reported on sycamore, which appears to be much less susceptible than London plane. It may affect either branches or trunks of trees. On London plane trees, it produces dark brown or black cankers on smooth bark. On old rough bark, diseased areas appear first as elongate depressions or furrows. Beneath these areas the inner bark is blackened and dead. The diseased areas continue to enlarge in succeeding years. The wood beneath the diseased bark is stained reddish brown or bluish black. The discoloration is most conspicuous in the wood rays and frequently penetrates to the center of an affected stem. Stems girdled by cankers die beyond the diseased areas.

Special care must be exercised when pruning is done to control this disease, since the fungus can be transmitted by pruning tools, wound dressings, and any other agencies or operations that make contact with the fungus on diseased trees and then with wounds on healthy trees. Pruning should be done in winter when the fungus is least active. All pruning tools should be carefully disinfected before being used on healthy trees. Denatured alcohol, 70 per cent, is a satisfactory disinfectant. Climbing ropes contaminated with the fungus can be disinfected by exposure to formaldehyde vapors for 3 hours (one-fourth pound formaldehyde in a 10-gallon closed container). Since the fungus can be carried in the ordinary types of wound dressings, a gilsonite-varnish type of paint which has 0.2 per cent phenylmercury nitrate mixed in it should be used on wounds of trees being treated for this disease.

WILLOW

Willow is susceptible to leaf and stem diseases. Trees may be killed by the stem diseases but not by the leaf diseases.

Tar Spot.—This leaf disease is caused by the fungus *Rhytisma salicinum*, which produces jet black, thick, tarlike, raised spots on the upper surfaces of leaves. The spots caused by this fungus on willow are usually much smaller than the spots caused by the tar spot fungus on maple (Fig. 61). In Illinois, willow is usually not severely damaged by tar spot. The disease can be controlled by sprays of organic mercury or copper sulfate and hydrated lime (Table 1). Two applications are recommended, the first application when the buds are opening and the second 3 weeks after the first. Raking and burning of leaves affected with tar spot will destroy the overwintering stage of the fungus.

Leaf Rust.—In Illinois, willow is affected occasionally by two fungi that cause leaf rust. One fungus, *Melampsora bigelowii*, has larch and the other, *M. abieti-capraearum*, has fir as an alternate host. Leaf rust caused by either fungus produces golden yellow to orange, powdery pustules on the lower surfaces of leaves during the summer. By late summer and autumn, these pustules become dark brown or black. They may be scattered or so closely crowded that the entire lower surface of an affected leaf appears powdery. Leaf rust on willow usually causes insufficient damage to warrant treatment for its control.

Cytospora Canker.—This stem disease, caused by the fungus *Cytospora chrysosperma*, produces cankers on branches and trunks of willow similar to the cankers described on poplar (Fig. 79). The treatment given for the control of this disease on poplar is effective on willow. Species of willow resistant to this disease should be used when available. Black willow and peach willow are reported as resistant to Cytospora canker.

Crown Gall.—This stem disease, caused by the bacterium *Agrobacterium tumefaciens*, produces swellings or warty, tumorlike galls on many species of trees and shrubs (Fig. 23). On most trees the galls are confined mainly to the bases of the trunks or the roots. However, on willow and poplar the galls may appear on the branches also. Severely affected trees are retarded in growth, and affected roots and branches may die. Crown gall usually causes very little noticeable damage on large trees, but it has been known to kill young trees.

Young trees affected with galls should be destroyed. Affected branches on large trees should be removed. In nursery plantings where crown gall occurs, all diseased stock should be destroyed. Wounding of stems and roots of healthy plants should be avoided, since infection occurs through wounds. Susceptible stock should not be planted in soil infested with the crown gall organism.

TREES RELATIVELY FREE OF DISEASES

Many native and naturalized trees in Illinois are relatively free of diseases. Some of these trees grow large and are used for shade as well as for ornamental purposes. Others grow as large shrubs or small trees and are used mostly for ornamental purposes. The group of large trees includes ailanthus, bald cypress, beech, black locust, ginkgo, hackberry, hickory, honey locust, Kentucky coffee tree, larch, magnolia, mulberry, Osage orange, sweet gum, tulip tree, tupelo, and walnut. The group of small trees includes dogwood, hop hornbeam (ironwood), hornbeam (blue beech), pawpaw, persimmon, plum, sassafras, shadbush (serviceberry), and water elm. Some of these trees, especially walnut, are subject to frequent attacks by insects, and some have habits of growth or other characteristics that make them undesirable in some situations.

A supplementary list of trees that are relatively free of diseases in Illinois is given below. Many of these trees are used only occasionally in shade and ornamental plantings, a fact that may account for the general absence of diseases. The large trees include Amur corktree, Douglas fir, European alder, fir, hemlock, Japanese pagoda tree (Chinese scholar tree), Katsura tree, larch, Paulownia, sourwood, yellowwood, and Zelkova. The small trees include arbor-vitae, Franklinia, goldenrain tree (China tree, varnish tree, or pride-of-India), Japanese snowball, Laburnum, quince, Russian olive, sea buckthorn, silverbell, yew, and ornamental forms of cherry and peach.

Table 1.—Spray chart for some important diseases of Illinois trees.

Season	Plant	Disease	Material in 100 Gallons of Water	Number of Sprays	Days Between Sprays
April–May	Hawthorn, crab apple, etc.	Rusts	Ferbam (*Fermate* or *Niagara Carbamate*), 2 lb. or Thiram (*Thylate Thiram Fungicide*), 2 lb.	4–5	7–10
April–May	Juniper	Rust	Cycloheximide (*Acti-dione* or *Actispray*), 50 (380 mg.) tablets	1	
April–May	Sycamore	Anthracnose	Organic mercury (*Puratized Agricultural Spray*, 1½ pt. first spray, 1 pt. second spray, or *Coromerc*, 1½ lb. first spray, 1 lb. second spray)	2	14
April–May	Juniper	Twig blight	Organic mercury (*Puratized Agricultural Spray*, 1 pt., or *Coromerc*, 1 lb.) or Copper sulfate, 8 lb.; hydrated lime, 8 lb.	5	10
April–May	Pine, spruce, Douglas fir	Tip blight	Organic mercury (*Puratized Agricultural Spray*, 1 pt., or *Coromerc*, 1 lb.) or Copper sulfate, 8 lb.; hydrated lime, 8 lb.	3	10–14
April–May	Pine	Needle blight	Organic mercury (*Puratized Agricultural Spray*, 1 pt., or *Coromerc*, 1 lb.) or Copper sulfate, 8 lb.; hydrated lime, 8 lb.	2	21
April–May	Maple, willow	Tar spot	Organic mercury (*Puratized Agricultural Spray*, 1 pt., or *Coromerc*, 1 lb.) or Copper sulfate, 8 lb.; hydrated lime, 8 lb.	1–2	21

Table 1.—(Concluded.)

Season	Plant	Disease	Material in 100 Gallons of Water	Number of Sprays	Days Between Sprays
April–June	Crab apple, hawthorn, mountain ash	Scab	Organic mercury (*Puratized Agricultural Spray*, 1 pt., or *Coromerc*, 1 lb.) or Dodine (*Cyprex*), 1 lb.	2–4	14
May–June	Horse-chestnut, buckeye	Leaf blotch	Dodine (*Cyprex*), 2 lb. or Zineb (*Parzate* or *Dithane Z-78*), 1½ lb.	2–3	10–14
May–June	Ash, maple, oak	Anthracnose	Organic mercury (*Puratized Agricultural Spray*, 1 pt., or *Coromerc*, 1 lb.) or Copper sulfate, 8 lb.; hydrated lime, 8 lb.	2	10–14
June–July	Elm	Black leaf spot	Organic mercury (*Puratized Agricultural Spray*, 1 pt., or *Coromerc*, 1 lb.) or Dichlone (*Phygon XL*), 1 lb., or Copper sulfate, 8 lb.; hydrated lime, 8 lb., or Wettable sulfur, 3 lb.	2	14
June–July	Walnut	Leaf spot	Organic mercury (*Puratized Agricultural Spray*, 1 pt., or *Coromerc*, 1 lb.)	2	21
June–July	Hawthorn	Leaf blight	Cycloheximide (*Acti-dione* or *Actispray*), 5 (380 mg.) tablets	1	
			or Dodine (*Cyprex*), ¼ lb.	2–3	14
June–July	Elm	Phloem necrosis (leafhopper)	Special methoxychlor or DDT formulations (pages 27, 28, 51)	2	35–40
July–August	Juniper	Rusts	Ferbam (*Fermate* or *Niagara Carbamate*), 2 lb.	3	21–28

Table 2.—Equivalent amounts of chemical compounds for 100 gallons and 1 gallon of spray.

Chemical Compound	Material in 100 Gallons of Water	Material in 1 Gallon of Water
Cycloheximide	50 (380 mg.) tablets	½ (380 mg.) tablet
Soybean flour	4 ounces	¼ teaspoon
Organic mercury	1 pint	1 teaspoon
Dichlone	1 pound	2 teaspoons
Dodine	1 pound	2 teaspoons
Zineb	1½ pounds	2 teaspoons
Ferbam	2 pounds	4 teaspoons
Thiram	2 pounds	5 teaspoons
Wettable sulfur	3 pounds	1 tablespoon
Copper sulfate	8 pounds	2 tablespoons
Hydrated lime	8 pounds	4 tablespoons

Note: Teaspoon and tablespoon measures are [illegible] level full and are approximate equivalents.

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