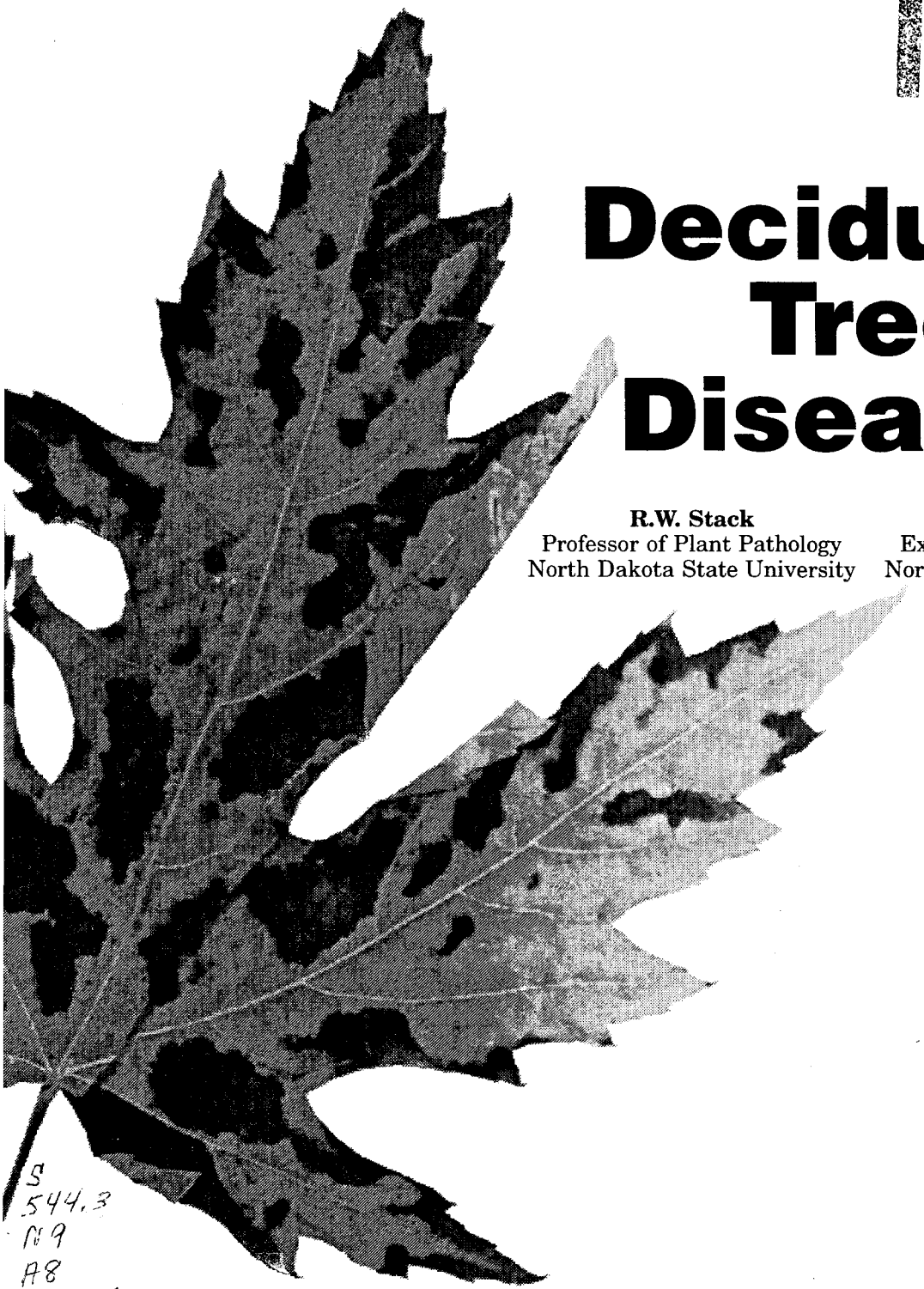
PP697 (Revised)

NEW

Deciduous Tree Diseases



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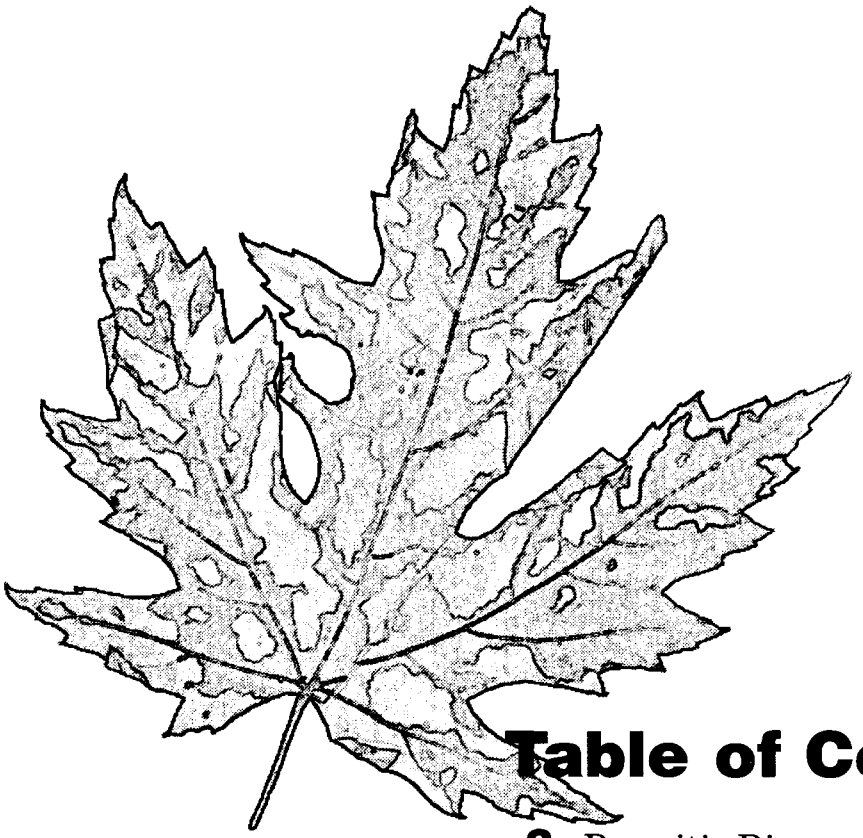

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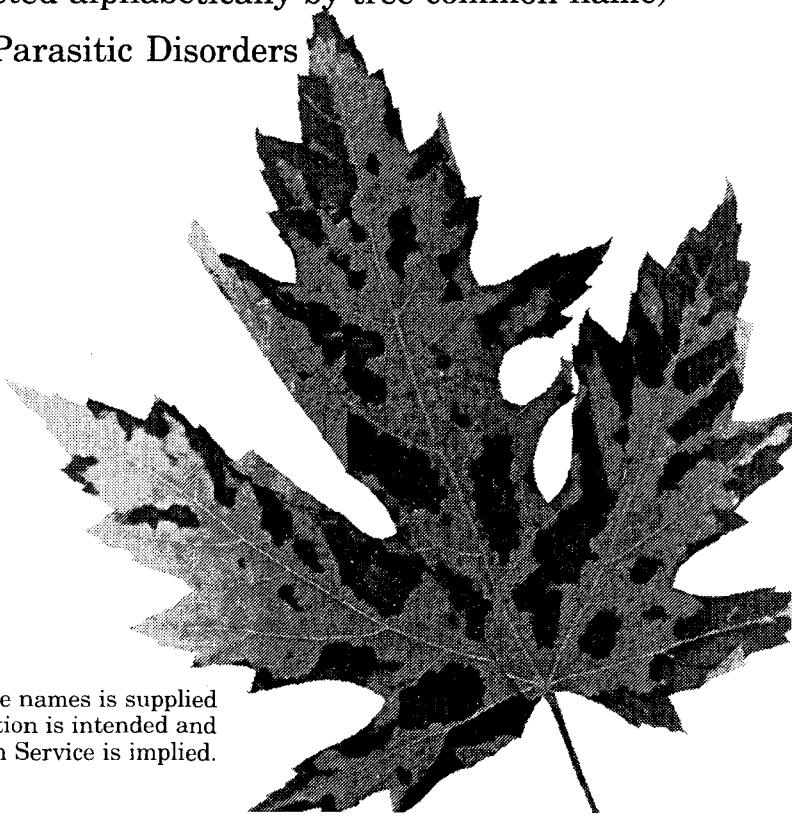

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Parasitic Diseases of Widespread Occurrence

Many tree problems are caused by the action of one or more living organisms. Organisms which cause disease are called pathogens. The most common tree pathogens are fungi, a large and diverse group of plants lacking chlorophyll which derive their nourishment by parasitizing green plants, thereby causing disease. Most fungi are microscopic, but a few, especially the wood-rotting fungi, produce large, often colorful, fruiting bodies as mushrooms or conks. Some tree diseases are also caused by bacteria and viruses.

Some types of pathogens infect many different tree species with similar disease symptoms. Other pathogens attack only a specific tree or only certain cultivars of a tree. Diseases of the first type will be considered in this section. Diseases unique to specific trees will be considered under the tree name in the second section on Parasitic Diseases of Specific Trees.

Powdery Mildew

■ Powdery mildew is a common foliage disease on nearly all kinds of trees. Powdery mildew appears as a white growth on the surface of leaves. The powdery appearance comes from millions of tiny spores of the causal fungus, which are spread in air currents to cause new infections. Tiny black dots found in the powdery patches are another type of spore body by which the fungus survives the winter. Trees most commonly affected by powdery mildew are linden, crabapple, catalpa and chokecherry, but almost any tree or shrub, including alpine current and rose, may be infected at some time or other. Powdery mildew is especially common on lilac. Because the usually dry climate of North Dakota is unfavorable for the humidity-loving powdery mildew fungi, the disease is seldom a severe problem here (Figure 1).

Control: Occasional or late-season infections are seldom important enough to warrant chemical control. If necessary spray with wettable sulfur at 2 to 4 pounds per 100 gallons (1 to 2 tablespoons/gal.) unless specified otherwise on the label. Sulfur may injure tender foliage, especially in hot weather. Do not use sulfur on walnuts, as injury may occur. Funginex can also be sprayed on lilac at a rate of 1 tablespoon per gallon.

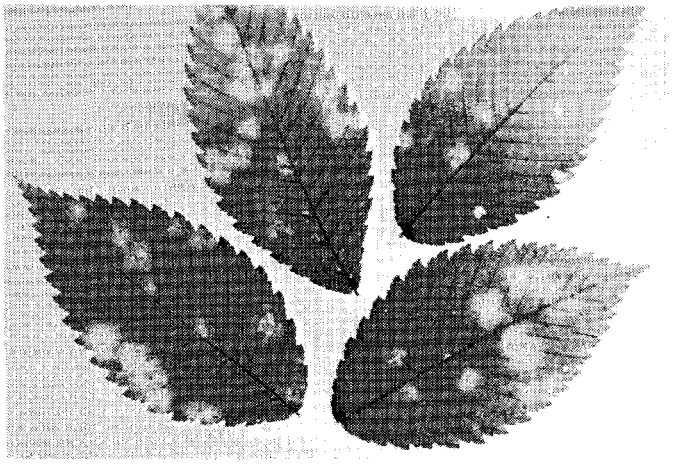

Figure 1. Powdery mildew on leaves of hop hornbeam.

Sooty Mold

■ Sooty mold, as the name implies, is a black growth on the surface of leaves, especially those in shade. The sooty mold fungi are not plant parasites but grow on the sweet honeydew deposited by various insects, especially aphids. Although unsightly, it seldom damages the tree. Sooty mold may occur on any tree but is most common on boxelder, elm, linden, and maple.

Control: Control depends on reducing the numbers of the honeydew secreting insects in the tree. Honeydew on leaves of small trees can be reduced by directing a stream of water over the foliage at frequent intervals.

Verticillium Wilt

■ Verticillium wilt, caused by the soil-borne fungus *Verticillium albo-atrum*, causes light colored leaves with a dull appearance in early summer. The leaves then begin to drop without wilting, starting at the bases of affected branches and progressing upward. The symptoms may involve only one side of the tree or they may involve the entire tree. In severe cases, and on highly susceptible trees such as sugar maple, entire branches may wilt and die. Dry leaves remain attached to these branches. Stunting occurs in trees that have been affected for several seasons. When an affected branch is cut off, a ring of discolored wood can be seen, with the color varying from gray to light or dark brown to green. If the bark is peeled back, discolored streaks can be seen in the wood (Figure 2). On elm, streaking caused by Verticillium resembles that from Dutch elm disease. A laboratory test is needed to be sure which organism is present.

The Verticillium fungus invades through the root system. Many tree species are susceptible, but the danger is greatest in a highly susceptible tree such as maple, catalpa, elm or stone fruit. The fungus attacks over 300 species of cultivated plants.

There is no good control for verticillium wilt. Sometimes a tree will recover if affected branches are pruned out and proper fertilizing and watering are provided to help promote vigorous growth. If a tree must be removed because of verticillium wilt, do not plant another susceptible tree in the same spot, since the Verticillium fungus survives a number of years in the soil. Plantings on land formerly in potatoes may be particularly likely to get verticillium wilt.

The following trees have been reported as resistant to verticillium wilt:

Birch	*Betula*
Hornbeam	*Carpinus*
Hawthorn	*Crataegus*
Honey Locust	*Gleditsia*
Flowering Crabapple	*Malus*
Willow	*Salix*
Mountain-ash	*Sorbus*
Pine	*Pinus*
Spruce	*Picea*

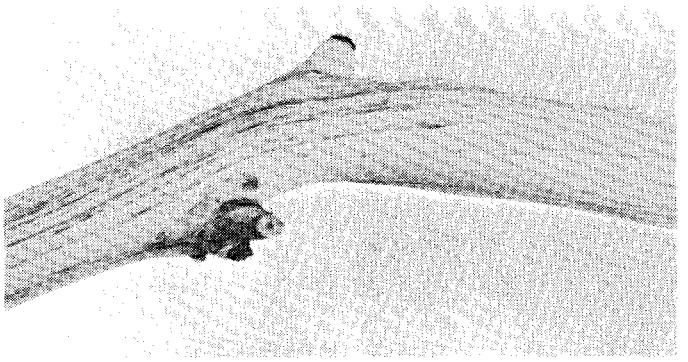

Figure 2. Streaking in wood by Verticillium wilt. Bark has been removed from this branch to show the characteristic streaking of sapwood caused by Verticillium wilt.

Canker

■ The term "canker" is used to describe a killed area in the bark on the branch or trunk of an infected tree. More than 20 species of fungi that cause canker diseases are found in North Dakota. These fungi commonly invade wounded or injured bark tissues to form a canker and subsequently produce reproductive structures called fruiting bodies. Spores from these fruiting bodies serve as inoculum for new infections. Cankers may be "superficial," forming on the outer portion of the bark and doing little damage, or "cambial" when extended into the cambium, where the bark sloughs off and sapwood is exposed allowing subsequent decay to develop in woody stem tissues.

Annual cankers are active for one growing season, and infected tissues are sloughed off or healed over by callus (Figure 17, page 25). New cankers may form, but existing cankers cease to develop.

Perennial cankers are most conspicuous and destructive. There are two types. In target cankers (Figure 14, page 20) a succession of callus tissue repeatedly forms on canker margins over a period of years. Diffuse cankers are generally oval in shape and either sunken or swollen, little or no callus is formed, and stems, twigs and branches are girdled.

Infections of living trees by canker fungi are influenced by site, age, tree vigor, environmental conditions and cultural practices. Stress by drought, lack of fertility, insect defoliation, or herbicide damage predisposes trees to canker. In general, cankers are more prevalent on young trees, on suppressed low vigor trees, or on trees at poor sites. Cankers most often occur on trees predisposed to infection by environmental stresses such as herbicide drift, defoliation by insects or chemicals or root damage.

Control: A sound control program for canker diseases must be based on knowledge of the causal organism, the host tree, the cultural and environmental conditions under which the trees are grown, and available control methods. Control involves both disease prevention and treatment. While homeowners may be able to justify control measures, they may not be economical in most windbreak situations in North Dakota.

Disease prevention involves growing vigorous trees to prevent entrance of pathogens into the bark. Wounds are essential for establishment of most canker infections. The best preventive measure is to avoid unnecessary wounds, especially in the immediate area of active cankers containing fungus spores. Establish new plantings on good sites, use vigorous planting stock, fertilize trees to promote growth, and control weeds for several years after planting. Improve vigor of landscape trees by deep watering or trickle irrigation, especially during dry summer months, and maintain good drainage. Protect trees from wounds or injuries. Sunscald control measures may also be implemented. See winter damage under Non-Parasitic Disorders.

It is difficult to cure infected trees by pruning diseased branches, since pruning frequently causes increased exposure and sun injury to remaining branches. In the case of landscape or severely storm damaged trees, dead, dying, or severely cankered branches may be pruned from infected trees during winter or early spring, but not at other times.

Leafspots

■ Localized infections of leaves ("leafspots") on many trees are caused by a variety of fungi and some bacteria. Positive identification usually requires laboratory diagnosis. Leafspot diseases are seldom of sufficient importance in North Dakota to warrant control measures. The few exceptions which may require control are noted under specific diseases for that tree species.

Leafspot fungi infect leaves by spores which are dispersed by air currents or splashing rain. Infection usually requires moisture, such as dew, fog, or rain. Leafspots are more likely to occur on trees growing in shade, crowded together or in low spots or frost pockets. The foliage on such trees tends to remain wet longer following rain or dew.

Leafspots increase in frequency late in the summer as leaves begin to senesce (Figure 3). Buildup of leafspots on autumn leaves generally does not affect the health of the tree and is the beginning of the natural process of decay by which the leaf is returned to the soil.

Control: Good cultural practices usually give sufficient control. To minimize leafspot problems, avoid crowding plantings too closely. Thin out branches to open up the tree crown, but don't top or dehorn. Rake up leaves in fall and bury or compost them. Plant different kinds of trees in mixture. Fertilize trees in spring with a complete fertilizer. Water trees deeply during dry spells.

When fungicides are used, they must be applied **prior to** buildup of disease to effectively control leafspotting fungi. If severe leafspotting and/or defoliation occurs for several years, chemical control may be necessary, but the causal agent should be identified first (submit samples to the NDSU Plant Diagnostic Laboratory through your county agent). Timing of protectant fungicide sprays is critical and varies for different fungi. Correct timing is a key to effective chemical control.

Heart Rot

■ Heart rot in living trees is caused by fungi which have the ability to decay wood. These fungi gain entrance to the wood of the tree through wounds, branch stubs, etc., which expose the bare wood. The fruiting bodies, mushrooms or "conks," are common on trunks of decaying trees. Production of fruiting bodies on a living tree is a sign of extensive decay in the stem at that point. A useful rule of thumb might be that a cubic foot of wood has been decayed for each conk produced. Heart rot fungi do not invade living wood of healthy trees. As long as the tree is growing vigorously the rot will be confined to a small central core of the trunk and the structural integrity of the tree will be maintained. If the tree is weakened for any other reason or fresh wood exposed by severe pruning or storm damage, then the decay fungi can advance to more and more wood (Figure 4). When this happens the tree may become unsafe and the risk of wind or storm breakage greatly increases.

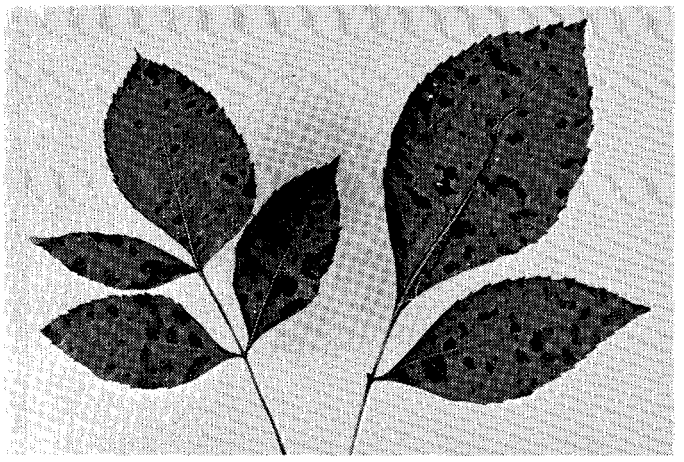

Figure 3. Fungal leafspot on green ash. Compare the irregular distribution to the regular pattern of environmental scorch shown in Figures 18 and 19.

Control: Avoid pruning wounds which expose large areas of wood. Shape trees when young so major branch removal will not be necessary later. Remove broken branch stubs following storm damage. Keep trees growing vigorously. Have trees suspected of having heart rot or hollows checked by a trained arborist to determine if sufficient live wood is present for structural safety. Your local city or state forester can recommend a reputable professional. Check such trees every few years to be sure new growth is maintaining sound structure. Large trunks and main branches with extensive decay may have little sound wood to support the tree (Figure 5).

Figure 4. Cottonwood branch with heart rot. The entire discolored center of the stem is decayed. The decay started from an untrimmed branch stub.

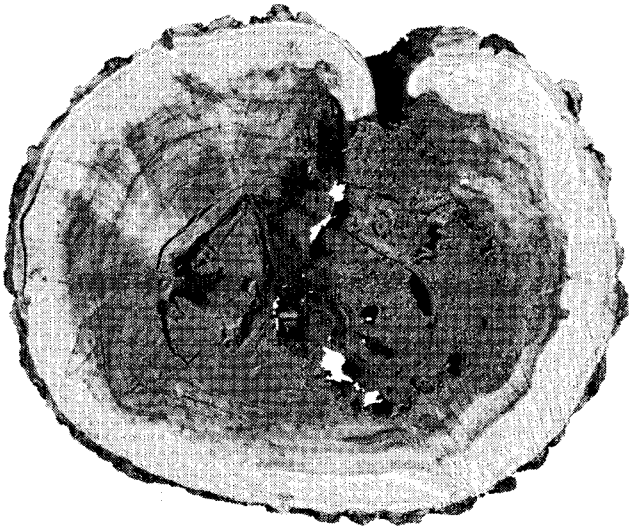

Figure 5. Cross section of severely decayed boxelder. Decay has progressed to the point where part of the center is hollow. The concentric rings of discolored wood show the advance of the decay fungi. Only the thin ring of white wood around the outside of this tree was structurally sound.

Parasitic Diseases of Specific Trees

Apple (*Malus* spp.)

The most common and severe diseases of apple are fireblight, scab and rust. Short descriptions follow. For more complete information on apple diseases, see Circular PP-454, Diseases of Apples and Other Pome Fruits, available from your county agent.

Fireblight is a common disease of apples, crabapples and mountain ash. Shoots become curled at the tip and blackened as if scorched by fire. Blossoms may also wilt, fruiting spurs may turn black and be killed, and suckers may be curled and blackened.

Fireblight is caused by a bacterium that invades the water conducting tissues of the tree. It overwinters in cankers on larger branches. These often form around a diseased sucker or fruiting spur. The bark on cankers is slightly sunken and discolored.

Control. Prune out diseased cankers in late winter. Sterilize pruning tools with 10% bleach, full strength Pine Sol, Lysol (use the type with the red label), or denatured ethyl alcohol (*eg.* shellac thinner). Bleach and Pine Sol are corrosive; be sure to wash and oil pruning tools after using these products. Streptomycin should be applied every four to five days at blossom time to apples if daytime temperatures exceed 65 degrees Fahrenheit.

Scab is common on apples and crabapples following wet weather. Feathery olive brown spots develop on the leaves. Later, these may become scabby in appearance. Severe scab can result in leaves yellowing and premature leaf drop. Fruits may also be infected; if the infection occurs before the fruits are full sized, the fruits will be distorted.

The apple scab fungus survives the winter on fallen apple leaves. Infection is favored by rainy weather.

Control. Rake and destroy fallen apple and crabapple leaves in the fall. To control apple scab infections during the summer, captan or benomyl plus captan fungicides can be used on apples, and chlorothalonil can be used on ornamental crabapples.

Rust produces yellow orange spots on leaves of apples, crabapples, hawthorn and juneberry. Tiny cup-like structures develop on the undersides of leaves. Juniper is the alternate host. On juniper the rust forms galls on the branches and twigs. Wet spring weather favors the formation of gelatinous horns on the galls. These horns release spores. Spores from juniper infect apples and related hosts; spores from apples and related hosts infect juniper.

Control. Pick galls off juniper in the spring to break the fungus life cycle. Don't mix junipers and susceptible crabapples in the same planting. Sulfur fungicide may be used on apples and chlorothalonil may be used on ornamental crabapple. Other products are available to commercial orchardists.

Apricot

■ See under **Cherry**.

Ash

(Green, Black, Manchurian, 'Marshall,' 'Summit') (*Fraxinus* spp.)

Anthracnose is the most common malady of green ash in North Dakota. Ash anthracnose is caused by the fungus *Gnomoniella fraxini*. It infects buds, leaves and sometimes twigs. Spring infection of buds or expanding leaves causes necrosis and distortion of leaves, the most typical symptom of ash anthracnose. Often such leaves have irregular brown blotches associated with leaf veins (Figure 6). Whole shoots may be stunted and the leaves deformed or killed. Infections occurring later, after leaves have expanded, cause small brown circular lesions which may later expand or coalesce.

In some years anthracnose is associated with extensive defoliation of ash trees in May or June. The exact conditions under which defoliation occurs are not known, nor are the reasons why it occurs in some years and not others.

The ash anthracnose fungus develops best at temperatures of 60 to 70 F. Wet weather in May favors anthracnose development.

Control: Rake up and destroy (burn, bury or compost) leaves in autumn to reduce the disease carryover. Prune out cankered branches and remove twiggy growth to promote air movement within the crown. Fertilize trees in spring to promote vigorous growth.

Where trees are attacked by anthracnose repeatedly, protectant sprays may be desired. Timing of fungicide application is critical if it is to do its job of protecting new growth. Three applications are best. Apply the first spray just as buds are beginning to swell but before bud break. Apply the second spray when buds show green tips and the third when leaves are half grown. The first spray should be lime sulfur; the other two sprays should be Daconil 2787 Flowable at 2 pints per 100 gallons of spray solution (two-thirds tablespoon per gallon) or Daconil Ultrex at 1.4 pounds per 100 gallons.

Scorch. See under Non-Parasitic Disorders.

Rust. Ash rust, caused by *Puccinia sparganioides*, is more of a curiosity than a real problem. Ash rust attracts attention because of the bright orange color of the fungus fruiting structures and the deformities which it causes on petioles and leaves. This rust alternates its hosts. The orange spores produced on ash do not reinfect ash but rather infect a wild grass (cordgrass, *Spartina* spp.). The spores produced in fall on the grass are responsible for infection of ash leaves the following spring. Since cordgrass often grows in wet areas or ditches, ash trees in the vicinity may show more severe rust.

Control: No control is needed on established trees.

Heart Rots. Several wood-rotting fungi attack living green ash trees. The most common is *Fomes fraxinophilus*. Two other fungi, *Polyporus sulfureus* and *Phellinus punctatus*, also cause heart rots in living ash trees in North Dakota. Heart rots are much more severe in mature and overmature trees in native woodlands. When purchasing a building lot or a home in a naturally wooded area, examine ash trees carefully for evidence of heart rot – especially that caused

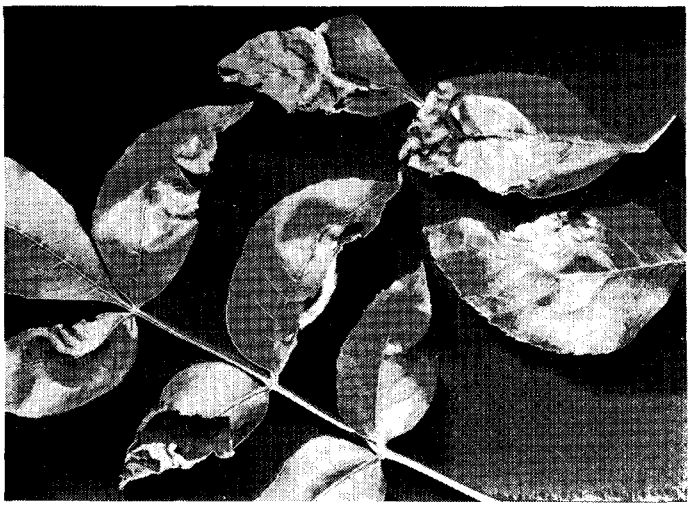

Figure 6. Ash anthracnose. Leaves show distortion and killed areas typical of ash anthracnose.

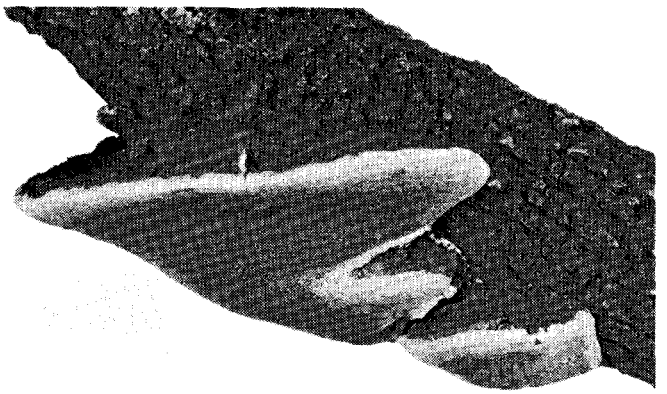

Figure 7. Conk of *Fomes fraxinophilus*. The cause of ash heart rot, this fungus is widespread, especially on native trees. Presence of conks indicates extensive decay of the wood.

by *Fomes fraxinophilus* (Figure 7). Infected trees on such sites often have serious structural defects and will need to be removed for safety. See "heart rot" under Parasitic Diseases of Widespread Occurrence at the beginning of this circular for management.

Leafspots. Several fungi cause leafspots on ash. None merit chemical control under ordinary circumstances, except in nurseries. See "leafspots" under Parasitic Diseases of Widespread Occurrence at the beginning of this circular.

Ash Yellows is a new name for a problem that has been around for many years. For more than 50 years foresters have described a slow decline of ash trees. Although environmental factors may cause a slow decline, ash yellows can also cause such a decline in individual trees. The disease, caused by a phytoplasma-like organism, is common in southern Wisconsin and Minnesota, has been observed in southeastern North Dakota, and one infected tree has been observed in the Badlands of southwestern North Dakota.

Infected trees usually show slower growth, about 70 percent of normal. They may also show decline, dieback and occasionally may develop dense clusters of short, twiggy branches known as witches' brooms.

Epicormic sprouts near the base of the tree occur in a small portion of infected trees. When present, these sprouts are diagnostic. Clusters of spindly twigs develop in the epicormic sprouts. The leaves in these sprouts are light green or develop chlorosis between the veins. Dieback of these twigs often occurs in the winter. The leaves may be simple or, if compound, the number of leaflets may be reduced. The sprouts often are only about 15-18 inches long, although in some cases they may be several feet long.

Since only a small portion of trees show epicormic sprouts or witches' brooms and many trees show no obvious symptoms, a laboratory test is required to confirm presence of ash yellows. Several laboratory tests have been used. One of these, called the DAPI test, is quick and reliable, especially if used on a root sample. This test is being used for diagnosis of the disease in Minnesota and North Dakota. Information on this test is available from your state's plant diagnostic laboratory.

Little is known about the means of spread of this disease, although insect transmission is likely. Infected green ash trees which lack severe symptoms will likely survive for many years if given good culture, watering and fertilization. The disease on green ash is generally far less severe than on the highly susceptible white ash of the eastern United States.

Aspen

■ See under **Poplar**.

Basswood

■ See under **Linden**.

Birch (*Betula* sp.)

Two birches are commonly planted in North Dakota. One is the paper birch (*B. papyrifera*), native in Minnesota and in some forested areas of North Dakota. The other is the introduced European white birch (*B. alba*) and its cultivated forms (cutleaf weeping birch). North Dakota conditions are not the best for growth and longevity of birches. Even where paper birch occurs in North Dakota as a native, its development and lifespan here are less than the optimum for the species.

Leafspots. Several fungi cause leafspots or blotches on birch. None merit chemical control. See "leafspots" under Parasitic Diseases of Widespread Occurrence at the beginning of this circular.

Chlorosis. Chlorosis or leaf yellowing is a common malady of birches in North Dakota. See "chlorosis" under Maple.

Scorch. Birches are susceptible to leaf scorch, which may appear on leaf margins or at the tips (see "scorch" under Non-Parasitic Disorders). Scorch on birch may be associated with wetwood or with decline (see "decline" below).

Herbicide Injury. Birches are very sensitive to herbicides applied to soil, especially dicamba (Banvel). This chemical may be used in some lawn fertilizer preparations. Heavy application of dicamba may cause rapid, complete defoliation. Such defoliated trees may not die and may leaf out normally the next year if the chemical is not used again. Milder effects of herbicides may be leaf distortion, chlorosis or scorch.

Birches may also show effects of phenoxy herbicide drift. See "herbicide injury" under Non-Parasitic Disorders.

Heart Rots. The wood of birch is very decay-susceptible. Several fungi cause rot in living trees (Figure 8). The most common are *Fomes fomentarius*, *Daedalia* spp., and *Polyporus squamosus*. See "heart rots" under Parasitic Diseases for symptoms and control. Because birch wood is so decay susceptible, it is very important to avoid large wounds such as are caused by removal of major branches. Do not attempt to head back large birch trees. Birch trees showing dieback and having conks or mushrooms of decay fungi on the trunks probably are safety hazards and should be removed. Consult your city forester or a trained commercial arborist.

Decline. "Decline" is a term used by pathologists and arborists to describe a gradual dying of trees where no single cause is obvious. Birch decline has been reported in the woodland areas of the Great Lakes states in native birch stands. A similar type of gradual dying has been observed in older birch trees in North Dakota cities.

Although the exact cause of birch decline is not known, it appears to be set off by drought, possibly coupled with root damage or other stress factors. Trees under stress conditions may become prey to pests or diseases not affecting healthy trees. Declining birch trees often have canker fungi associated with dying branches, but it seems likely that the fungi are only attacking the already weakened tree.

Figure 8. *Fomes fomentarius* **conk on white birch. Sometimes called "horse's hoof" or "false tinder conk." Presence of several conks indicates extensive decay.**

The bronze birch borer is attracted to weakened birch trees, and once it becomes established it often kills the tree. Identification and control of bronze birch borer is described in NDSU Extension Circular E-296, Insect Pests of Trees and Shrubs. One important source of bronze birch borer infestation in eastern North Dakota may be birch firewood imported from adjacent forest areas where natural borer populations are high.

Boxelder

■ See under **Maple**.

Buckeye (and Horse-chestnut) (*Aesculus* sp.)

Scorch. By late summer some leaf scorch must be considered usual on buckeye in North Dakota. See "scorch" under Non-Parasitic Disorders. Symptoms of verticillium wilt may resemble scorch. Scorch is sometimes confused with leaf blotch.

Leaf Blotch. Buckeye leaf blotch or leaf blight is caused by the fungus *Guignardia aesculi* (Figure 9). The blotches start as small irregular reddish-brown spots with yellow margins. These later enlarge and coalesce. Premature leaf drop may also occur. Minute black fruiting bodies of the fungus are found in the brown blotches.

Control: Gather and dispose of fallen leaves by burying, composting, or burning. In most seasons in North Dakota, late season appearance of leaf blotches is not important and adequate control will be obtained by removal of fallen leaves. Leaf blotch may be confused with scorch.

Powdery Mildew. Two species of powdery mildew sometimes infect buckeyes. (See "powdery mildew" under Parasitic Diseases).

Winter Injury. The true horse-chestnut (*A. hippocastanum*) of the eastern and southern U.S. is beyond the range of hardiness in North Dakota. If planted here it may suffer severe winter killing each year – if it survives at all. The tree planted in North Dakota as buckeye (*A. glabra*) is hardy and also more variable. Many hardy individuals are found growing well in North Dakota. Even so, freezing injury may occur in some winters (see "winter damage" under Non-Parasitic Disorders). Winter-killed shoots should be pruned back only after new growth has started. Because most "Ohio buckeyes" are really of hybrid parentage, some individual trees may be winter-injured more or less often than others.

Verticillium Wilt. Buckeye is susceptible to verticillium wilt. Mild symptoms may resemble scorch. More severe symptoms may result in death of one or more branches. (See "verticillium wilt" under Parasitic Diseases of Widespread Occurrence).

Butternut

■ See under **Walnut**.

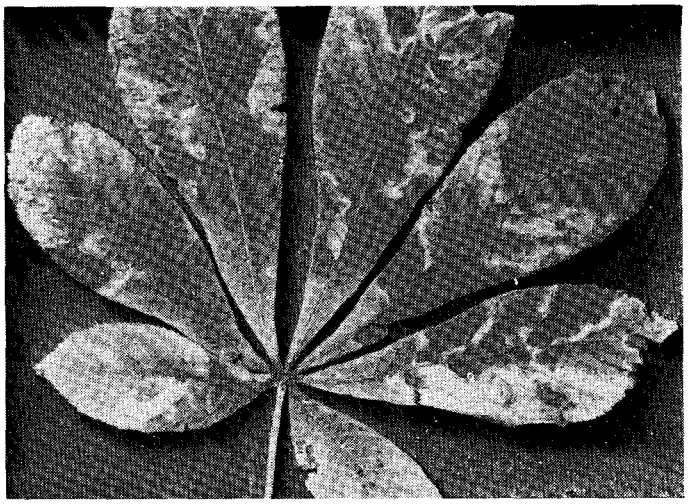

Figure 9. Guignardia leaf blotch. This is common on both horse chestnut and buckeye.

Catalpa (*Catalpa* sp.)

In milder climates, the catalpa is a showy ornamental tree. Most of North Dakota is at the margin of catalpa's hardiness range, although some trees survive well. Winter injury, especially dieback of shoots and buds, is the most common problem with the tree in our area. Catalpa is susceptible to leafspots, powdery mildew, and verticillium wilt, all of which are discussed under Parasitic Diseases of Widespread Occurrence.

Cherry (*Prunus* spp.)

The most common and severe diseases of cherry and chokecherry are black knot, plum pockets and X disease. Short descriptions follow. For more complete information on diseases of cherries and chokecherries, see Circular PP-689, Disease Control in Cherries, Plums, and Other Stone Fruits, available from your county agent.

Black Knot is easily recognized by the hard black swellings or "knots" on smaller branches. These knots eventually girdle and kill branches. New knots develop a felty olive green appearance about blossom time. This is due to the release of spores that start new infections in wet weather.

Control. Prune all developing knots at blossom time, cutting 4-5 inches below the knot. Annual pruning may be required for several years to achieve control. Best control is achieved by pruning combined with use of a fungicide. Lime sulfur may be applied as a dormant spray before bud-break. Once the buds break, use captan plus benomyl.

Plum Pockets infects cherry, chokecherry, wild plum, some domestic plum hybrids, sand cherry, Nanking cherry and wild black cherry. The fruits become hollow and bladder-like and are greatly enlarged. Shoots may be deformed and curled on some stone fruits and a leaf curl and witch's broom may develop on others.

Several related Taphrina species infect stone fruits. Spores are dispersed in early spring and become lodged in bud scales and other small crevices and remain dormant until bud break the following spring.

Control. Use a delayed dormant spray just before bud break. Lime sulfur can be applied in spring once the temperatures are above freezing, or Bordeaux mixture can be applied. Lime sulfur can also be applied in the fall after leaf drop.

X Disease is currently epidemic throughout the northern Great Plains. Many native and planted groves of chokecherries have been wiped out. X disease is caused by a phytoplasma which becomes systemic in the plant. The disease is spread by leafhoppers and takes several years to develop. First symptoms are early fall color. In subsequent seasons plants show bronzing or reddening of leaves in mid summer. Shoot dieback occurs and eventually the plants die. There is no cure. Do not replant chokecherries near affected plants.

Cottonwood

■ See under **Poplars**.

Crabapple

■ See under **Apple**.

Elm (*Ulmus* spp.)

(American or white elm, red elm, Siberian or so-called "Chinese" elm)

Despite many problems with disease and injury, the elms, especially American and Siberian elms, are by far the most commonly grown trees in North Dakota.

Dutch Elm Disease. This lethal disease of American elm was first found in North Dakota in 1969. At the present time it has spread throughout North Dakota. Because of its importance, Dutch elm disease (DED) is the subject of a special NDSU Extension Circular, PP-324, Dutch Elm Disease. Several other diseases of American elm cause symptoms which may resemble DED. These are verticillium wilt, native elm wilt, botryodiplodia canker, and wetwood.

Wilt. Several diseases may cause wilting of foliage on elms. Wilted foliage usually dries up quickly under dry North Dakota conditions. Wilting may be a symptom of Dutch elm disease. In this case the foliage almost always turns yellow before wilting and turns brown after wilting. Symptoms of DED progress down the tree. Wilted brown leaves hang on the tree (See NDSU Extension Circular PP-324, Dutch Elm Disease).

Verticillium Wilt causes a wilting very similar to Dutch elm disease but leaves do not always yellow before wilting. Often a whole branch or side of the tree may wilt suddenly and leaves may be shed from wilted branches. Laboratory diagnosis is the only sure way to distinguish DED and verticillium wilt (see "verticillium wilt" under Parasitic Diseases of Widespread Occurrence).

Native Elm Wilt or Dothiorella Wilt, like the two other wilts above, is caused by a fungus which grows in the vascular, water-conducting tissues of the tree. The native elm wilt fungus infects through wounds in leaves or branches. It may cause leaves to wilt or turn yellow, cause shoots to die back or form cankers in branches. Major branches or entire trees are seldom killed outright.

Control: Prune out and destroy infected branches, cutting at least a foot below affected areas. Fertilize trees of low vigor. Prevent insect injuries.

Wetwood. Wetwood is a bacterial infection in the heart of the tree. It is evidenced by discoloration of the wood and sap oozing from wounds or cracks in the bark. Virtually every elm tree is infected with wetwood; usually it is more of a nuisance than a real problem. Occasionally, individual young elms may be severely injured by wetwood. Leaves may wilt and yellow, and branches may die back. Usually these symptoms appear during or following a drought. Affected trees may recover in following seasons with adequate rainfall.

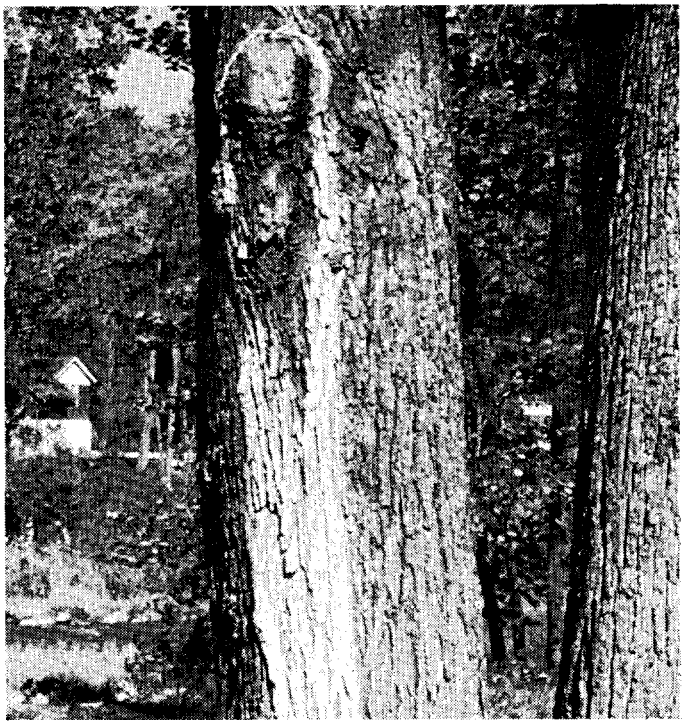

Figure 10. Wetwood slime flux on American elm. The flux is oozing from an old branch stub.

The external symptom of wetwood, an oozing of sap, is termed "slime flux." It is associated with branch stubs, pruning wounds or other stem injuries. The slime flux on the outside of the tree results when internal pressure in the wood, caused by growth of the bacteria, forces out the sap. This bacteria-laden sap supports the growth of yeasts and molds which produce the foul odor and texture on the flux area (Figure 10).

Wetwood sap is toxic to living plant tissue. Wounds with wetwood seldom heal completely and often become larger due to the toxic flux. Such openings may properly be termed wetwood cankers.

Wetwood is most often noticed on elm (both American and Siberian). It is also very common on cottonwood and on willows. Wetwood occurs to a lesser extent or with less obvious symptoms on birches and maples.

Severe wetwood may cause foliar symptoms and dieback of branches. On American elm and cottonwood, foliage often shows characteristic toxicity symptoms of chlorosis and scorch; ends of affected branches may die back. These symptoms seem to be more pronounced during or following dry seasons and may disappear completely in succeeding wet years.

There is no cure for wetwood. The objectionable flux may be directed away from the trunk with a tube inserted into the bark so that the flux drips to the ground instead of running down the trunk. Dealing with fluxing by use of drain tubes inserted into the wood has recently been questioned, as the drilling of drain holes may actually aid the spread of the bacteria inside the tree.

Leafspots. While several fungi cause leafspots on elms, only one is of importance. This is *Stegophora (Gnomonia) ulmea*, the cause of elm black leafspot (Figure 11). Infected leaves show small grayish, irregular spots on the upper leaf surface. Often these are surrounded by a yellow halo. Later the spots become black and thickened. If infection is heavy, leaves may turn yellow and fall prematurely. Elm black leafspot infects all species of elm. It is often more severe on leaves in shade and lower in the crown. Individual trees vary in susceptibility to elm black leafspot, so some trees may be heavily infected while others nearby are not.

Control: Rake up leaves in fall and burn, compost, or bury them since the fungus survives the winter in fallen leaves. This will usually give adequate control under North Dakota conditions. If elm black leafspot is severe or occurs repeatedly, fungicidal sprays may be used. If sprays are needed, use a fixed copper fungicide or Fore fungicide at 1.5 pounds or 1.2 quarts per 100 gallons of water. Apply three sprays, the first as leaf buds open, the others at 10-day intervals. Fungicidal control depends on **protecting** leaves **before** infection, hence timing is important.

Scorch. Leaf scorch is common on elm in North Dakota. (See "scorch" under Non-Parasitic Disorders). Scorch-like symptoms may indicate a root problem (see "root disturbance" under Non-Parasitic Disorders) or a wilt disease.

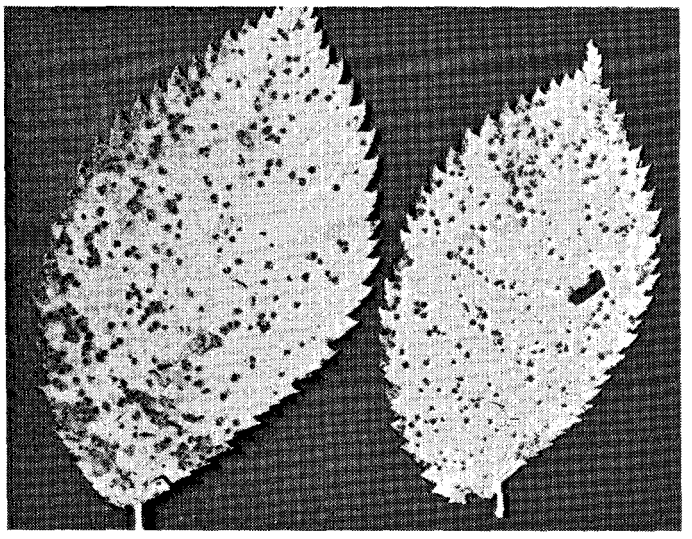

Figure 11. Elm black leafspot. The small spots are covered by dark, raised structures (stromata) of the causal fungus. Spots are often (but not always) surrounded by a yellow ring.

Herbicide Injury. Elms, especially Siberian elm, are sensitive to phenoxy herbicide drift and fumes, as from 2,4-D. The response in elm is

curling and discoloration of newly developing leaves (Figure 20, page 29). Trees need not be sprayed directly to be affected. Individual elm trees vary in their sensitivity to 2,4-D. Symptoms may be evident on some trees in a row and not on others. Elms may appear to suffer no permanent injury from low levels of phenoxy herbicide exposure. Later growth appears normal and trees survive for many years. (See "pollution" under Non-Parasitic Disorders). Research in South Dakota has shown that phenoxy herbicide increases the susceptibility of Siberian elm to canker fungi.

Elm Yellows. Elm yellows (formerly called phloem necrosis), is a lethal disease of American elms. Once thought to be a virus disease, yellows is caused by phytoplasma — a tiny relative of the bacteria. The disease is transmitted by leafhoppers from tree to tree. Scattered reports of elm yellows have been noted in North Dakota and in adjacent states. Symptoms include decline and early fall color. Inner bark on infected trees has a wintergreen odor. There is no cure. Trees with elm yellows will gradually die. They never recover. Infected trees should be removed because as they become weaker they will act as "brood trees" for elm bark beetles.

Cankers. Several fungi cause cankers on elms in North Dakota. The most common are *Botryodiplodia hypodermia* and *Tubercularia ulmea*. Tubercularia cankers occur mostly on Siberian elm, while Botryodiplodia attacks both Siberian and American elm.

Botryodiplodia canker develops on the branches of American elm in natural woodlands and in landscape plantings and on Siberian elm in all situations. Infected bark becomes reddish-brown to brownish-black, watersoaked and very soft. Cambial and sapwood tissues immediately beneath infected bark become dark reddish-brown, and a distinctive line of demarcation separates healthy and infected bark. Siberian elm foliage on stems girdled by cankers initially becomes chlorotic, then wilts and dies. Adventitious sprouts frequently develop below girdling cankers and produce a witches' broom appearance. Eventually, Siberan elms may be killed. On American elm, *Botryodiplodia* is usually restricted to branch tips and weak shaded branches. The leaves on cankered branches turn bright yellow in mid-summer but generally do not wilt. The bright yellow "flags" caused by this canker are sometimes confused with Dutch elm disease. Cankered branches usually die back gradually from the tip. Botryodiplodia infects through wounds over a wide temperature range.

Tubercularia ulmea can develop on trunks, branches, and twigs of affected trees, especially Siberian elm. Dead branches with dead leaves still attached can indicate the presence of the canker. The surface of infected bark is reddish-brown and becomes brown to black as it dies and dries out. *T. ulmea* readily colonizes dead or broken branches, thus its presence does not necessarily mean it killed the branch or tree.

Control: See under Parasitic Diseases of Widespread Occurrence – Cankers.

Hackberry (*Celtis* sp.)

Leafspots. See under Parasitic Diseases of Widespread Occurrence.

Scorch. See under Non-Parasitic Disorders.

Powdery Mildew. See under Parasitic Diseases of Widespread Occurrence for mildew on leaves and also "witches' broom" below.

Witches' Broom. Many people recognize hackberry by the conspicuous witches' brooms on the branches (Figure 12). These bunched twiggy growths occur as a result of a dual infection by a tiny gall mite and the powdery mildew fungus. The galls do not harm the tree but may be unsightly (or picturesque, depending on your taste).

Control: There is no practical way to control the brooming. If brooms are objectionable they can be pruned off.

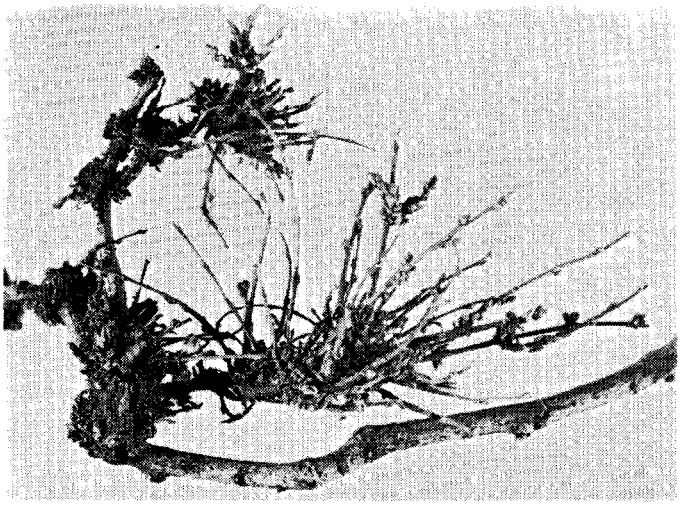

Figure 12. Witches' broom on common hackberry. Several brooms of different sizes are shown along with remnants of old ones that have died.

Nipple Gall. Not a disease. Galls formed on underside of hackberry leaves are caused by the jumping louse. See Insect Pests of Trees and Shrubs (NDSU Extension Circular E-296).

Honey-Locust

(*Gleditsia triacanthos*)

Winter Injury. The honeylocust and its thornless clones ('Moraine,' 'Imperial,' 'Skyline,' 'Sunburst') are of marginal hardiness in North Dakota. Slow growing forms may be more hardy. Avoid high fertility to minimize winter injury. (See "winter injury" under Non-Parasitic Disorders).

Leafspots. Several fungal leafspots may occasionally appear on honey-locust but are of little consequence. (See "leafspots" under Parasitic Diseases of Widespread Occurrence).

Powdery Mildew. See under Parasitic Diseases of Widespread Occurrence.

Cankers. May be caused by *Tubercularia*, *Nectria* and *Thyronectria*. These cankers have caused serious problems in states where honey-locust was widely planted following the loss of elms to Dutch elm disease. Cankers occur on twigs, large branches or even the main stem. Both young and older trees are affected. Cankers appear as elongate (sometimes a foot or more), sunken, dark areas in the bark. The killed bark soon dries out and cracks, exposing the wood. Cankers continue to enlarge and may girdle the stem. Sunken dark-red cankers may also form at branch crotches or at pruning wounds. Cankers may be more common in periods of drought and on trees in stressful situations such as parking lots.

Control: The best control for cankers is to prevent conditions which favor their development. Avoid wounds or injuries. Protect young trees from winter injury. Plant only the hardiest cultivars, such as Imperial' and Skyline.' Water and fertilize young trees to promote vigorous growth. Prune off cankered branches and destroy them by burying or burning. Sterilize tools between cuts. Examine nursery stock carefully before purchase. Avoid buying trees with wounds or abrasions on bark. See under Parasitic Diseases of Widespread Occurrence for more information.

Hawthorn (*Crataegus* spp.)

Although hawthorn is not generally considered a fruit tree, the disease problems of hawthorn are those of its closest relative, the apple, and are covered in a companion NDSU Extension Circular PP-454, Diseases of Apples and Other Pome Fruits." The most common problems of hawthorn are rust, fireblight and leafspots. See under **Apple**.

Hop Hornbeam or Ironwood (*Ostrya* sp.)

The hop hornbeam is a North Dakota native which deserves to be planted more widely. It has few disease problems. Occasionally leafspots, mildew or scorch may be of minor importance.

Horse Chestnut

■ See **Buckeye**.

Ironwood

■ See **Hop Hornbeam**.

Kentucky Coffee Tree

(*Gymnocladus* sp.)

Few diseases have been reported on this tree. Several leafspots (see Parasitic Diseases of Widespread Occurrence) are known to occur, but none is considered serious. This is one of the most disease-free trees suitable for planting in North Dakota. Winter injury (see Non-Parasitic Disorders) may be a problem, although some large trees are found in eastern North Dakota. Trees grown from reliable seed sources should be winter hardy.

Linden or Basswood

(*Tilia* sp.).

Leafspots. Several leafspots and a leaf blight or anthracnose have been reported on linden but none is serious in North Dakota. See "leafspots" under Parasitic Diseases.

Powdery Mildew, Sooty Mold. See Parasitic Diseases of Widespread Occurrence.

Herbicide Injury. Linden is less sensitive to 2,4-D than boxelder or Siberian elm but may suffer damage if sprayed directly. Leaf curling or distortion is the usual symptom.

Linden is quite sensitive to injury from dicamba (Banvel), an herbicide often included in lawn fertilizer mixtures. Symptoms of dicamba injury are leaf-cupping or leaf distortion, including leaves that are thicker and darker green than normal. Because this chemical is in the soil, the effects may persist for a long period.

Control: Do not use fertilizers containing dicamba around or under linden trees.

Scorch. Lindens are quite susceptible to scorch on the leaf margins (Figure 19, page 28). See "scorch" under Non-Parasitic Disorders.

Verticillium Wilt. Linden is susceptible to verticillium wilt although reports from North Dakota are rare. See under Parasitic Diseases of Widespread Occurrence.

Winter Injury. Lindens, especially young trees, may be subject to both sunscald and freezing damage. See under Non-Parasitic Disorders. Such injuries may provide infection sites for canker-causing fungi.

Cankers. Canker fungi – especially *Cytospora* sp. – are sometimes associated with dying branches or with young trees which have died. Many of these canker-causing fungi do not attack healthy established trees but can attack following injuries, sunscald, etc. – especially on newly transplanted or weakened trees.

Control: The best control for cankers is to prevent conditions which favor their development. Avoid wounds or injuries. Protect young trees from winter injury. Plant only hardy cultivars. Water and fertilize young trees to promote vigorous growth. Prune off cankered branches and destroy them by burying or burning. Sterilize tools between cuts. Examine nursery stock carefully before purchase. Avoid buying trees with wounds or abrasions on bark.

Maple (*Acer* spp.)

(Silver, *A. saccharinum*; sugar, *A. saccharum*; Norway, *A. platanoides*; red, *A. rubrum*; Amur, *A. ginnala*; mountain, *A. spicatum*; boxelder, *A. negundo*)

The maples are a large diverse group of trees, only a few of which are grown in North Dakota.

Winter Injury. The sugar, silver, and Amur maples and the boxelder are winter hardy in North Dakota; even so, young trees may be damaged by sunscald if not protected. Many cultivars of Norway maple are of questionable hardiness and may suffer severely from winter injury, especially when heavily fertilized and watered. See "winter injury" under Non-Parasitic Disorders.

Poor Growth, Chlorosis, Dieback of red and sugar maples. Although their native range includes adjacent northern Minnesota and Canada, these species often do not succeed when planted in North Dakota. Trees or saplings collected from the northwest extremity of the native range may be better adaped to the Plains environment. This nonspecific disorder appears to be a root/soil problem. Neither species likes alkaline soils. There may also be problems with the ability of the essential symbiotic root-fungus associations called mycorrhizae to form in North Dakota soils.

Herbicide Injury (Boxelder blight). Boxelder is one of the most sensitive of all trees to phenoxy-type herbicides such as 2,4-D. Low level exposure produces leaf distortion while higher levels kill foliage. Such trees have a scorched appearance as if burned by flame. These extreme symptoms are common in remaining hedgerows alongside grain fields, but most of the boxelders in shelter plantings have succumbed to this problem. See "pollution injury" under Non-Parasitic Disorders.

Leafspots. Several leafspot fungi attack maples (Figure 13). See "leafspots" under Parasitic Diseases of Widespread Occurrence. The ocellate leaf gall insect causes a circular spot on maple leaves which is often confused with a fungal leafspot.

Leaf Galls. Several species of mite cause leaf galls on maple which may be confused with a disease. These galls may look like spines, or may be woolly or felty patches on the leaf surface and of different colors, often bright red, (see NDSU Extension Circular E-296, Insects of Trees and Shrubs, for description and controls).

Powdery Mildew. See under Parasitic Diseases of Widespread Occurrence.

Sooty Mold. Sooty mold is especially common on boxelder. See under Parasitic Diseases of Widespread Occurrence.

Verticillium Wilt. Maples are especially susceptible to verticillium wilt. See under Parasitic Diseases of Widespread Occurrence.

Chlorosis. The symptom called chlorosis is a yellowish coloration of the foliage. The leaves may turn pale yellow-green to bright yellow, depending on the tree species and the severity of the

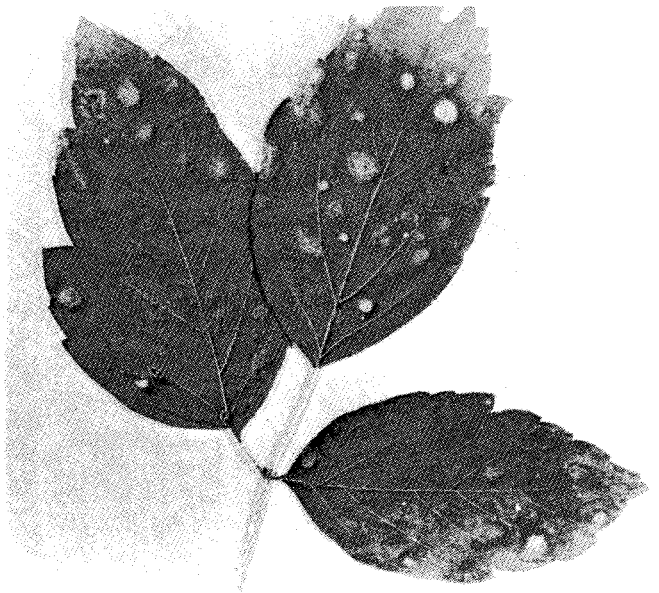

Figure 13. A leafspot of boxelder caused by *Cristulariella pyramidalis*. The large white circular spots show concentric zones.

problem. The leaves may be uniformly yellowish or, more often, the veins are green while the area between is yellow. Severe chlorosis may lead to scorch on leaf margins.

Chlorosis is usually caused by lack of some nutrient, especially iron or manganese, in the leaves. This deficiency may be due to lack of fertility, but may also result because the element, while present in the soil, is unavailable to the roots. This condition is especially common in alkaline soils such as occur over most of North Dakota.

Birches and maples seem especially prone to chlorosis, and should be avoided if high soil pH problems are known to occur. Chlorosis is extremely common on silver maples. Some trees may show severe chlorosis year after year and yet make good growth otherwise. Individual trees vary in appearance of chlorosis even when grown under identical conditions. No reason for this variability is known, other than genetic variation.

Control: Foliar applications of iron chelate or other iron-containing compounds will sometimes temporarily correct the chlorosis. Where practical, adjustment of the soil pH and proper application of micronutrient fertilizer may offer the best long-term solution. Micronutrient capsules implanted in the trunk may provide a remedy lasting for several seasons but mixed results have been reported from this therapy.

Cankers. The fungus *Eutypella parasitica* attacks maples and boxelder causing large perennial cankers on trunks or main branches. On sugar and Norway maple, eutypella cankers are elongate with conspicuous ridges of callus tissue around the sides (Figure 14). On sugar maple these cankers seldom girdle the stem but the enlarged, distorted growth around the canker and subsequent exposure of wood to decay fungi may structurally weaken the tree. On Norway maple, eutypella stem cankers can completely encircle the trunk causing top dieback. Cankers on Norway maple are often associated with frost crack or winter sunburn of the lower trunk.

On boxelder, eutypella cankers tend to be sunken and rounded, often nearly circular, while on Norway maple cankers are very elongate, especially when associated with cracks in the stem. In contrast to sugar maple, where bark on the canker face sloughs off, bark on faces of eutypella cakers on Boxelder and Norway maple remains attached.

Control: Protect stem wounds and pruning stubs. Small cankers may be carefully excised. When selecting those trees to leave on a new building lot, reject any trees with large cankers. When purchasing Norway maple nursery stock, examine the trunk carefully for canker infection.

Wood Decay and Heart Rots. The wood of maples, especially silver maple and boxelder, is very decay susceptible. Any pruning wound or injury which exposes the wood is an avenue for entry of decay fungi. Avoid major surgery whenever possible as large wound faces heal slowly and readily admit decay fungi. See "heart rots" under Parasitic Diseases of Widespread Occurrence.

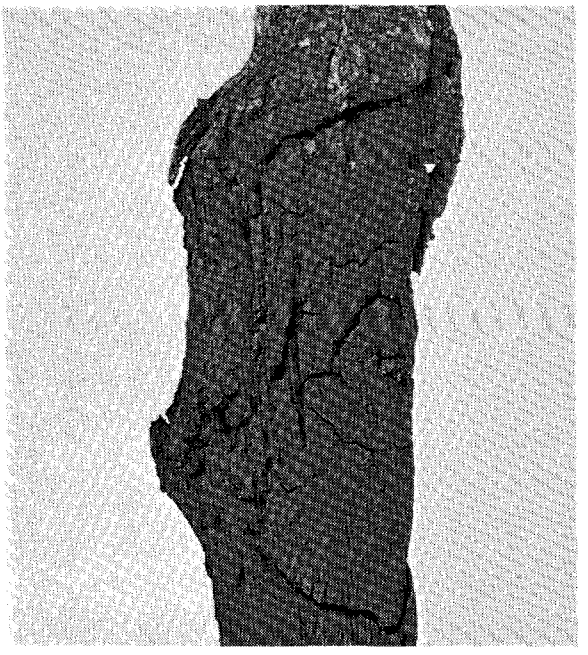

Figure 14. Eutypella canker on a sugar maple stem. This perennial canker causes the distortion shown here. Concentric rings on the canker face indicate successive years of growth.

The bright red coloration often seen in the wood of boxelder is caused by a fungus, *Fusarium lateritium*, which infects the wood. This fungus does not affect the soundness of the wood, but its presence often indicates decay fungi are also present (Figure 5, page 7).

Wetwood. See under Elm.

Mayday Tree (*Prunus* sp.)

■ See under **cherry**.

Mountain Ash (*Sorbus* sp.)

The mountain ash is a member of the rose family and closely related to apple and pear. Many of the same diseases such as fireblight and cankers occur on both mountain ash and apple. See under apple.

Oak (*Quercus* sp.)

Bur oak (*Q. macrocarpa*) is the common native oak in North Dakota.

Anthracnose, caused by the fungus *Gnomonia veneta*, is a serious disease of oaks, including the bur oak. The twiggy habit of bur oak is largely due to repeated infection by anthracnose.

The oak anthracnose fungus overwinters in fallen leaves, infected shoots, and in buds. The disease shows several different symptoms depending on the source and time of infection. There are three phases of this disease, twig blight, shoot blight and leaf blight. In the twig blight stage, buds are killed before they can begin to grow. Later, shoots may grow out from lower down on the branch. When this occurs repeatedly, "witches' brooms" or clusters of dead twigs may occur at ends of branches (Figure 15). In the shoot blight phase, new shoots are killed while they are expanding. Often blighted shoots appear scorched as if by fire. In the leaf blight phase of anthracnose, leaves may be distorted and partially killed at the tips or along veins. (Compare the leaf blight phase of ash anthracnose, Figure 6, page 9).

If infection occurs after leaves have expanded, circular to irregular brown spots may develop on the leaf. These spots may enlarge or coalesce in wet weather, blighting large areas of the leaf. Often all these phases of anthracnose are present together on different branches of the same tree.

Weather conditions in spring, when new growth is occurring, are the most important factors determining the severity of oak anthracnose. Mean daily temperatures between 50 and 57 F during shoot growth are most favorable for oak anthracnose infection. Cool, wet, late springs favor anthracnose development.

The anthracnose fungus is almost always present, even though weather may be unfavorable for serious disease development. For this reason a serious epidemic can occur even though symptoms have been virtually absent for several years.

Control: Repeated anthracnose attacks seldom permanently damage established bur oaks; in fact, the anthracnose-caused, gnarled, twiggy growth is sometimes considered picturesque and characteristic of the trees.

Figure 15. "Witches' brooms" on bur oak caused by oak anthracnose. Repeated killing of new shoots produces the twiggy branching shown here.

Young or recently transplanted trees and trees in nurseries may need protection from anthracnose. Spray protectant fungicides at properly timed intervals to prevent anthracnose infection. A dormant spray of lime sulfur at 1 gallon (30 percent) per 10 gallons (1.5 cups per gallon) or copper Bordeaux at label rate may help prevent bud blight. Do not apply lime sulfur after bud break.

Rake up and destroy (burn, bury, or compost) leaves in the fall. Broomed or cankered twigs may be pruned out. Fertilize and water to promote vigorous growth.

Oak Leaf Blister. This disease may go unnoticed unless a large number of leaves are severely infected or leaves begin to fall prematurely. The initial symptom is a slight yellowing of infected leaf tissue, followed by the formation of circular raised blisters on the leaves. Blisters form when infected cells are stimulated to enlarge, while surrounding noninfected cells remain rigid. Blisters are usually less than an inch in diameter, and the lower surface will appear gray as the fungus develops in the leaf tissue. Multiple infections cause a single leaf to become distorted. Premature defoliation may occur in early fall. The fungus survives on bud scales and in bark crevices.

Control: Particularly valuable ornamental trees may warrant treatment with a fungicide, which must be applied as a dormant spray to be effective. Use lime-sulfur at 10 tablespoons per gallon in the fall or in spring **before** bud break. Fungicides are not effective after leaves begin to develop because infection has already occurred. Collecting and disposing of infected leaves has no effect on the disease.

Leafspots. Several fungi cause spotting of oak leaves. Few are serious in North Dakota. See "leafspots" under Parasitic Diseases of Widespread Occurrence. Note: compare the leafspot phase of anthracnose.

Powdery Mildew. See under Parasitic Diseases of Widespread Occurrence.

Sooty Mold. Common on bur oak. See under Parasitic Diseases of Widespread Occurrence.

Scorch. See under Non-Parasitic Disorders.

Oak Wilt. Oak wilt is an important and serious disease of oaks in Wisconsin, Iowa and southeastern Minnesota. The nearest known locations of oak wilt are in Minnesota in counties around St. Cloud. **Oak wilt has never been found in North Dakota or in the northwestern part of Minnesota.**

All oaks can be infected by the oak wilt fungus but they vary in susceptibility. The red oaks are most susceptible and rapidly killed. White oaks are moderately resistant while bur oak is intermediate.

A drought-induced decline of oak in the Red River Valley and adjacent parts of northern Minnesota sometimes appears similar to oak wilt symptoms. A laboratory diagnosis is necessary to confirm the presence of oak wilt. Suspect trees should have samples taken as for Dutch elm disease (see NDSU Extension Circular PP-324, Dutch Elm Disease) and submitted to the appropriate state laboratory for diagnosis.

Decline. A slow decline or gradual deterioration of bur oaks is a common problem in newly built-up areas where the oaks were native. At first, leaves may be scorched or fewer than before; later, twigs and then branches die and eventually the tree becomes unsightly and is removed.

Although disease or insects may play a role in the final death of such trees, the real cause of the decline is root disturbance. Oaks are particularly sensitive to even small disturbances of their root systems. Even slight changes in drainage caused by installation of driveways near existing trees, installations of septic systems, etc., may send oaks into decline. Although care can prolong their demise, once large oaks begin to decline, the process is irreversible. Extraordinary measures to preserve native oaks near new construction are impractical or incompatible with modern construction methods. See "root disturbances" under Non-Parasitic Disorders.

Shoestring Root Rot. The oak root rot fungus *Armillaria mellea* often attacks roots of oak, especially trees which are stressed by drought or defoliation. This fungus fruits in the fall producing clusters of tan or yellowish mushrooms at the base of the infected tree. The color of these mushrooms gives the fungus its other common name, "honey mushroom." Many people consider this mushroom a delicacy and collect it in large quantities to eat.

Oak trees attacked by *Armillaria* often show a decline similar to that described above. In addition to the mushrooms in the fall, presence of this fungus can be determined by examination of the base of the tree. Black "shoestrings" or rhizomorphs of the fungus will be seen under the bark. The wood will be decayed with a whitish rot. Trees with substantial decay of the root collar may be easily blown down in windstorms.

Control: The fungus may survive many years in pieces of wood (trunk or roots) buried in soil. When removing a diseased tree, dig out butt and larger roots. Do not replant another tree in the same location.

Pear

■ See under **apple**.

Poplar (*Populus* spp.)

(aspen, cottonwood, hybrid poplars)

Septoria Leaf Spot. This disease is caused by *Septoria musiva* and occurs on native and hybrid poplars commonly grown in windbreaks and used in landscape plantings. Symptoms vary according to time of infection, hosts, texture and age of leaves. Four types of leaf spot symptoms occur: 1) Small flecks with angular margins; 2) white or silvery spots; 3) brown circular leaf spots with brown or yellow margins; 4) irregular shaped large tan spots in center with dark brown margins (Figure 16). Premature defoliation occurs on highly susceptible trees. With successive years this disease may predispose a tree to other disease pathogens.

Control: Plant tolerant or resistant clones. Sanitation in the field – burial or removal of leaves and stems – can reduce primary infections in the spring. In severe cases in landscape plantings, shortly after July 1 apply Daconil 2787 Flowable at two-thirds tablespoon per gallon (2 pints per 100 gallons) or Daconil Ultrex at 1.4 pounds per 100 gallons every seven to 14 days through the remainder of the growing season.

Marssonina Leaf Spot. This is a disease problem of native poplars, aspen, and hybrid poplars. It may severely defoliate susceptible trees well before normal leaf drop. The disease is caused by fungi in the genus *Marssonina*. Dark brown flecks, often with yellow margins, appear on leaves within a few weeks after leaves emerge in spring. Diseased leaves on

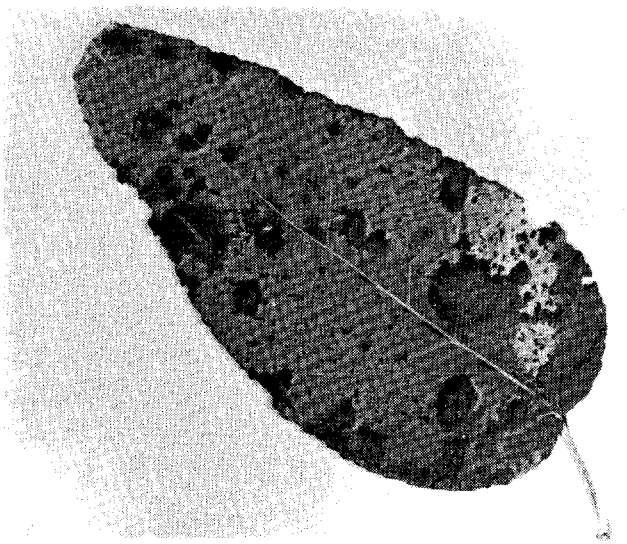

Figure 16. Septoria leaf blight on balsam poplar. Both small and large spots are present.

affected trees appear smaller than normal, turn yellow-bronze, and are shed prematurely. The fungus moves progressively upward in the crown. If viewed from a distance the diseased leaves appear bronzed. On more established plantings and in native stands repeated outbreaks result in branch dieback and predispose trees to secondary pests and low temperature injury.

Control: Plant poplars resistant to or tolerant of marssonina leafspot. Remove dead and infected twigs from diseased trees. Rake up and destroy fallen leaves during the growing season. For ornamentals apply Ortho Multi-Purpose Fungicide at three-fourths tablespoon per gallon of water, or Daconil 2787 at two-thirds tablespoon per gallon (2 pints per 100 gallons) or Daconil Ultrex at 1.4 pounds per 100 gallons at 7 to 14-day intervals starting July 1 of the growing season.

Poplars may be affected by other **leafspots, scorch, powdery mildew** or **wetwood**, all covered under "Parasitic Diseases of Widespread Occurrence" except scorch, which is covered under "Non-Parasitic Disorders."

Shoot Blight. Young shoots and leaves shrivel and turn black. The fungus *Venturia populina* and related fungi infect young succulent shoots and cause death. The disease is favored by moisture. It is more severe in wet weather and in shaded locations or where dew is frequent. Although temporarily disfiguring, shoot blight seldom damages established trees unless it occurs for several years in succession.

Control: Prune out affected shoots. Young trees and trees in nurseries may require fungicidal protection. Apply three sprays at 10-day intervals, beginning at bud break. Spray a fixed copper fungicide according to label directions.

Rust. Poplar rust is caused by the fungus *Melampsora medusae* and related species. Rust generally appears after midsummer. First symptoms are small yellow pustules on the lower leaf surface. These contain the yellow to orange uredospores by which the fungus spreads from poplar to poplar. Later in the season the leaf appears covered by orange to brown waxy crusts which are the overwintering stage of the rust.

Spores produced in spring from these overwintering stages on fallen leaves can infect nearby larch trees, if present. Later, spores produced on infected larch branches reinfect poplars. Since larches are absent over most of North Dakota, mid-to-late summer infections probably arise by wind-borne spores from adjacent areas.

Control: Rust may become a problem in North Dakota under certain moist environmental conditions. Early defoliation by rust may weaken young or newly-planted trees and can be a serious problem in nurseries.

Removal of fallen leaves will not control rust as the infectious spores are wind-borne, often from great distances.

Protectant fungicide sprays may be used where protection of young trees or nursery stock is needed. Use Funginex at 1 tablespoon per gallon at seven to 10-day intervals as needed.

Cankers. The single type of disease causing more problems on poplars than any other in North Dakota is cankering caused by parasitic fungi. Fungi in the genera *Cytospora*, *Phomopsis*, *Septoria*, and *Dothichiza* cause cankers on poplars. These fungi kill areas of the bark on branches and main stems. If the killed area (canker) is large enough or if several cankers grow together, the stem may be girdled and killed. Spores which spread the canker fungi are produced in tiny pimple-like fruiting bodies in bark of cankers. In wet weather they ooze from the bark and may be splashed about by wind and rain. The canker fungi infect healthy stems when the spores land on wounds in the bark. Even minute cracks or scars may be sufficient to let in canker fungi.

Bark on cankers is sunken and discolored. Foul-smelling sap often oozes from cankers. The pimple-like dark fruiting bodies form on the affected bark. Later, the bark may loosen and split or fall off, exposing the wood. If healing is taking place, the canker will be surrounded by raised ridges of callus tissue which gradually grow together to heal the canker. Cankers may be any shape, but are often diamond-shaped or elongate (Figure 17).

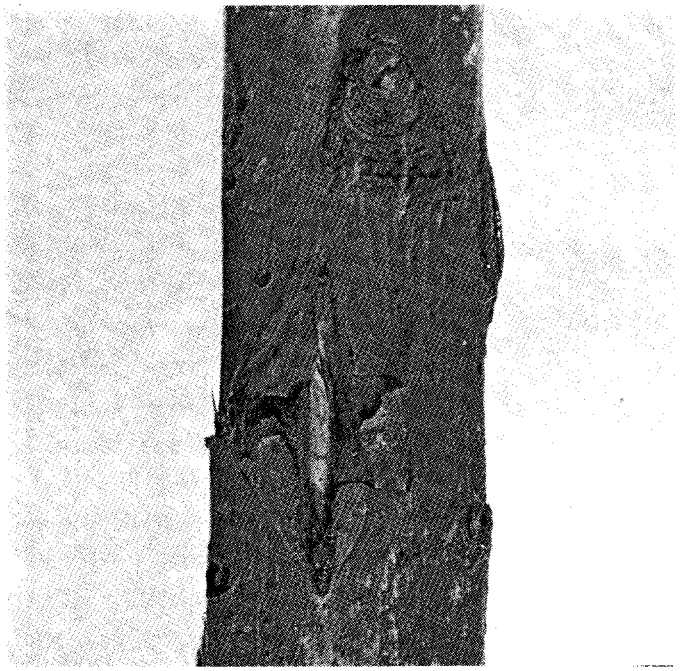

Figure 17. Annual canker on young cottonwood stem. The original diamond-shaped canker is evidenced by the torn bark. This canker is healing, as can be seen by the vigorous callus rolls at the sides.

Control: Certain poplar clones, particularly the Lombardy poplar (*P. nigra* 'Italica'), are extremely susceptible to cankers and should not be planted. Drought stress greatly increases the susceptibility of poplars to cankers. Keep trees well watered and promote good growth with proper fertilization.

Prune out cankered branches during dry weather and destroy by burying or burning. Avoid wounding trees. Treat pruning cuts with a fungicidal wound dressing. Protect young stems from sunscald in winter. Septoria canker may be controlled by utilizing septoria leaf spot recommendations. See "canker" under Parasitic Diseases of Widespread Occurrence for additional information.

Russian-Olive

(Elaeagnus angustifolia)

Scorch, Herbicide Injury, Winter Injury. See under Non-Parasitic Disorders.

Leafspots, Verticillum Wilt. See under Parasitic Diseases of Widespread Occurrence.

Rust. A leaf rust may damage leaves and cause some defoliation in certain seasons. No control is generally needed.

Stem Cankers. Several canker fungi attack Russian olive. These include *Phomopsis elaeagni*, *Botryodiplodia theobromae*, and *Tubercularia ulmea*.

These fungi invade the bark through wounds. Bark on cankers is at first sunken and may later dry up and split. Fruiting bodies of the causal fungus may appear on the bark. Cankers may increase in size until they girdle a branch or stem which then dies. If uncontrolled, cankering may gradually kill branch by branch until the tree dies or loses its usefulness and must be removed.

See "canker" under Parasitic Diseases of Widespread Occurrence for control.

Walnut (*Juglans nigra*) and Butternut (*J. cinerea*)

Leafspots. Several leafspot fungi attack walnut. See under Parasitic Diseases of Widespread Occurrence.

Anthracnose, Leaf Blight. See "anthracnose" under Ash.

Scorch. See under Non-Parasitic Disorders.

Winter Injury. Trees from different seed sources vary in hardiness. Plant only hardy sources. Understock used on named cultivars may affect hardiness. Butternut is of questionable hardiness in North Dakota, although some large specimens exist in the eastern part of the state. See "winter injury" under Non-Parasitic Disorders.

Willow (*Salix* spp.)

Several species of willows, both native and introduced, are widely planted in North Dakota. Willows are moisture-loving trees and planting on sites with adequate soil moisture will prevent many problems with scorch, cankers, etc.

Leafspots, Scorch, Winter Injury and Wetwood. See under Parasitic Diseases of Widespread Occurrence for leafspots and wetwood and under Non-Parasitic Disorders for scorch and winter injury.

Rust. Willow rust is caused by species of *Melampsora*, similar to the poplar rust fungus. See "rust" under Poplar for description of symptoms and control. Funginex is not labeled for rust control in willows.

Shoot Blight or Scab. Willow shoot blight, caused by the fungus *Venturia saliciperda*, is closely related to the fungus causing shoot blight of poplars. See "shoot blight" of Poplar for description of symptoms and control.

Cankers. Several fungi cause stem cankers on willow. The most important willow canker fungus in North Dakota is *Cytospora chrysosperma*. Cytospora cankers cause death of shoots and some larger branches. See "canker" under Parasitic Diseases of Widespread Occurrence for further description and control.

Heart Rot. Wood of willow is very decay susceptible and several wood-decaying fungi attack wood of living trees. Among the most important is *Trametes trogii*. See "heart rots" under Parasitic Diseases of Widespread Occurrence for control. Because willow is a weak-wooded tree and often develops hollow trunks, trees with any sign of decay fungi (mushrooms or conks) should be examined carefully for safety, if the trees are in yards, play areas, along streets, etc.

Non-Parasitic Disorders

Trees deteriorate and die for many reasons. As with people, trees may die from hunger, thirst, old age, toxic chemicals, or improper care. Disorders of this sort are termed **non-parasitic** or **abiotic** to indicate that the cause is not some living agent or pathogen. Abiotic disorders are seldom the cause of death of a tree but, all too often, they pave the way for some pathogen which could not attack a healthy tree directly. Non-parasitic disorders of trees most commonly encountered in North Dakota are scorch (desiccation injury), winter damage, and root injury.

Leaf Scorch

■ The symptom known as leaf scorch results when the roots are unable to supply enough water to replace that used by the leaves. For this reason scorch is most commonly seen following dry spells, drought, or on windy sites. The combination of environmental conditions which favor scorch occurs nearly every summer in North Dakota. By the end of the season many trees show leaf scorch symptoms.

The most common pattern of leaf scorch is a drying out and browning of the leaf margins (Figure 18). The symptom is often more severe on outer, more exposed leaves, especially on the sunward and windward sides of the tree.

Where hot drying winds occur for several days during the period of active tree growth, more severe scorch symptoms may appear. The outer parts of leaves or whole leaves dry up. Following such an episode new leaves will often form if moisture supplies to the roots are adequate.

Leaf scorch symptoms may also appear following damage or disease in the roots (see root disturbance below) or injury to the trunk. Scorch symptoms may also occur from salt damage, especially from deicing salt used on roads, sidewalks or driveways near the tree.

Elm, maple, linden, and walnut appear to be the species most commonly affected by scorch. Large-leaved trees such as catalpa or buckeye may also be more susceptible. Some leaf scorch on susceptible trees by the end of summer must be considered normal in North Dakota (Figure 19).

Control: In exposed areas, plant trees in groups rather than singly. Plant scorch susceptible trees in protected locations. Water young trees as needed and water deeply. Fertilize trees of low vigor. Do not plant shallow-rooted trees on droughty or excessively wet sites.

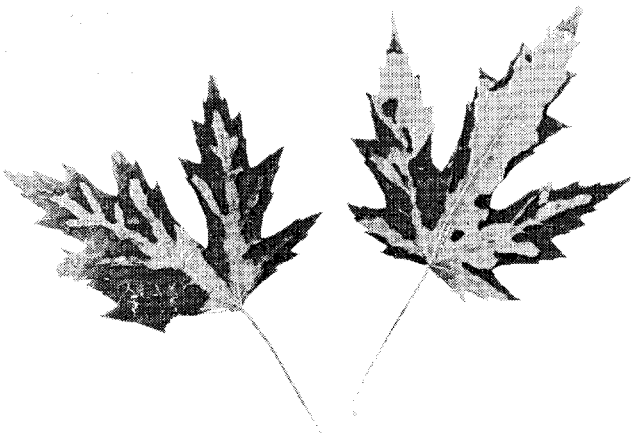

Figure 18. Leaf scorch on silver maple. The dark areas on margins and tips of the leaves are killed by hot dry winds.

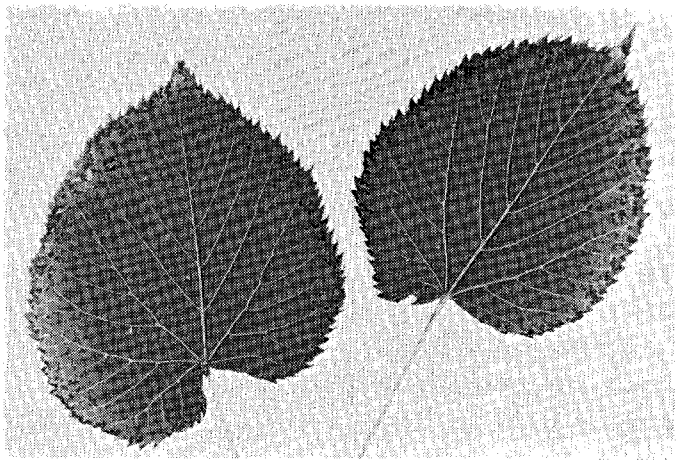

Figure 19. Leaf scorch on linden. Drying of leaf margins and between veins is common on many trees by late summer.

Winter Damage

■ Winter damage may take several forms on deciduous trees: frost cracks, bud or shoot death and sunscald.

Frost cracks develop from internal stresses in the tree trunk. Frequently these cracks open up in coldest weather and close again when the weather warms up. Ash and maple are especially prone to frost cracking. Frequently, cracks open in the same place year after year resulting in a callus ridge ("frost rib") down the side of the tree. As long as the tree is otherwise healthy, frost ribs do little harm, but if the tree also has heart rot or is hollow they may constitute a serious structural weakness. No control is known for frost cracking.

Bud or shoot death (freezing injury) occurs if temperatures get too low in winter or from frosts in early fall or late spring. Prolonged warm spells during the winter will cause this condition, particularly in those trees in which the rest period can be broken by low temperatures. It usually is aggravated if a warm period is followed by an extremely cold one. Buds or entire shoots may be killed. Buds may be injured sufficiently to allow entry of disease-causing fungi. Flower buds are more cold tender than leaf buds and may be killed while leaves are unaffected. This type of winter injury is most likely when non-adapted tree species or marginally hardy cultivars are planted in North Dakota. Occasionally, very unusual weather may cause injury even to otherwise hardy native trees.

Symptoms first become evident in spring when plants fail to flower or to leaf out. When new growth finally begins, shoots arise from older parts of the branches. Winter-killed twigs may be quickly colonized by weakly parasitic fungi. This can give a false impression that a parasitic disease is the cause. Excessive fertilizer levels or failure to reduce irrigation frequency in late summer will delay hardening off, which makes shoots more susceptible to injury.

Control: Do not use high nitrogen fertilizer (lawn fertilizer) under trees in late summer or early fall. Reduce or stop irrigation as fall approaches. Plant trees known to be hardy in North Dakota.

Sunscald or sunburn occurs in late winter when the sun is bright – especially if new snow is on the ground. Sunscald usually occurs on the south or southwest side of a tree. Thin bark on the tree is warmed enough to become active. When temperatures fall sharply at night, the inner living bark is killed. Thin-barked trees such as maple are most susceptible, especially when young.

Control: Sunscald on newly planted trees may be prevented by wrapping the trunks with burlap, kraft paper or special tree wraps. Trunks may also be shaded on the south and west side with boards or screens. Tree paints (white-wash) have also been utilized to reduce sunscald damage. Plant trees of marginal hardiness only in protected locations. Avoid frost pockets. Plant only hardy species or cultivars (see NDSU Extension Bulletin No. 13, Trees and Shrubs for North Dakota).

Air Pollution Injury

■ Although the levels of air pollutants such as sulfur dioxide (SO_2) or ozone (O_3) are generally low in North Dakota, locally high levels of SO_2 may occur downwind from power stations. Vegetation injury by SO_2 is similar to scorch (see previous section) in that parts of the leaves are killed, usually at the margins or between the veins. Pale killed spots may be found on the surface of the leaf as well.

The most common plant-damaging air pollutant in North Dakota is drift from herbicides. Low levels of volatile herbicides such as 2,4-D are carried many miles and are sufficient to damage sensitive species such as boxelder and Siberian elm, even in cities. Herbicidal injury is usually evident as deformation of young leaves and shoots. Leaves which develop before or after the exposure will be normal, so that affected foliage clothes only the middle part of the shoot (Figure 20). Higher dosages of herbicide will kill foliage or even shoots. This latter type of damage is common in field windbreaks.

Control: Minor deformity of sensitive species is uncontrollable as long as phenoxy herbicides remain in widespread agricultural use. Usually no permanent damage is done from low concentrations as the trees grow out of the symptoms. To prevent severe damage, avoid spraying trees when applying herbicides. In home yards, do not apply lawn herbicides within the dripline of trees. Do not spray trees with the same sprayer used to apply herbicides.

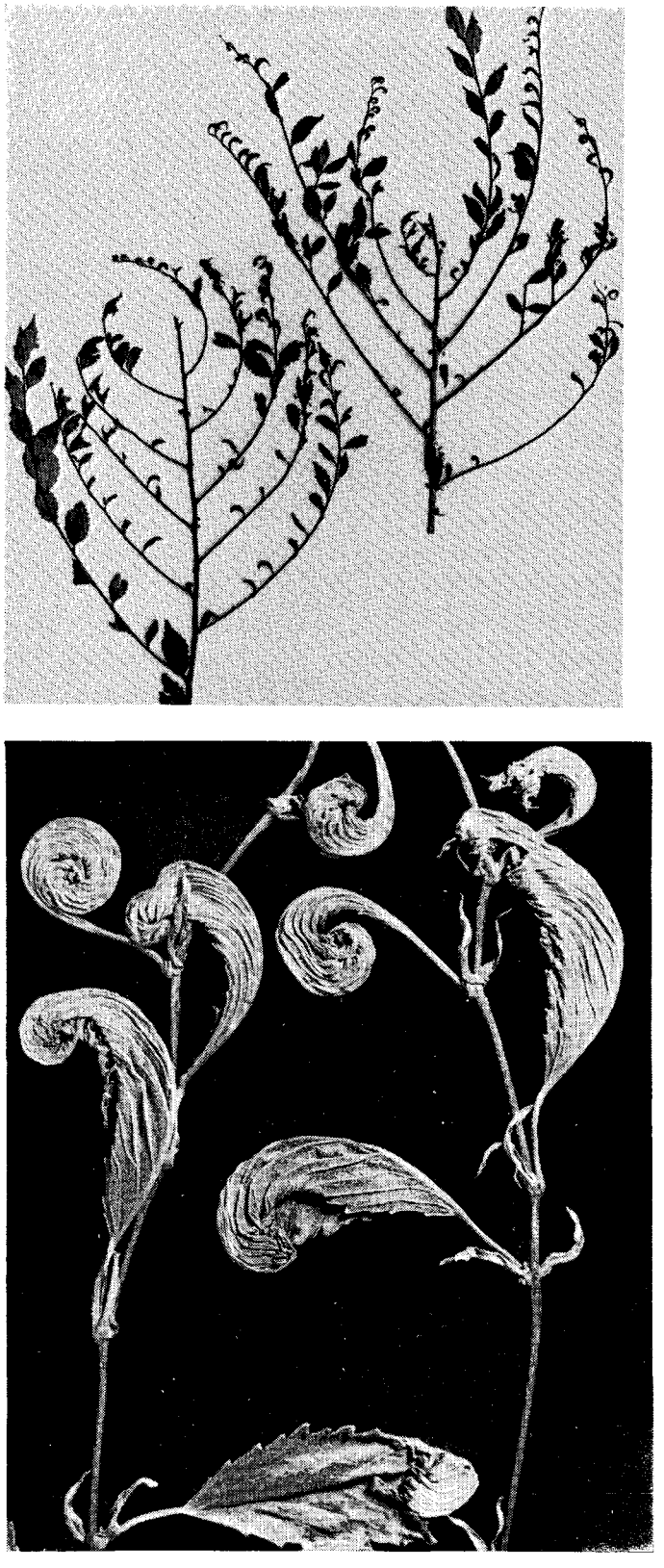

Figure 20. Herbicide injury to Siberian elm. Symptoms typical of 2,4-D injury.

(top) Branches showing different severities of leaf distortion. Leaves which grew out before exposure are normal.

(bottom)Extreme distortion resulting from a high level of herbicide.

Root Disturbance

■ One of the most common and yet least recognized causes of tree problems is root disturbance, often associated with some sort of construction activity. This may be laying of pipe or cable (Figure 21A), street widening, placing a new building in an older site or turning residential areas into parking lots.

Because young trees — and even moderately-sized ones — can be successfully transplanted, people sometimes think that root damage is of no consequence. An established tree has a wide, spreading root system which may extend as much as two to three times beyond the width of the canopy. Loss of a substantial part of this root system will result in decline of the tree, unless corrective measures are taken. Old or very large trees seldom have sufficient regenerative capacity to survive major root damage, although it may take such a tree several years to die (Figure 21B). Home builders or contractors frequently try to preserve trees by fencing off an area around them. This protects the trunk from damage but is of little help to the root system, which extends out well beyond the drip line of the tree crown. Excavation, even at a distance of 10 feet from the trunk of a large tree, may destroy 30 percent of the root system. It does not take major soil disturbance to cause damage. Cutting a narrow ditch for laying utility cable effectively disconnects the entire root system on that side of the tree.

Changes in grade will also damage tree root systems by upsetting the balance of air and water the roots need to survive. Soil compaction from heavy vehicles can kill roots. When tree roots are damaged by any of these causes, the tree begins to decline. The first symptoms may be leaf scorch. Later, twigs and shoots die back, then whole branches may die. Death of the tree may follow.

Trees vary in their ability to tolerate root damage. The American elm is one of the most tolerant, and it may take several years to die following severe root disturbance. Some other trees, such as oak and cottonwood, are extremely sensitive to any root disturbance and large trees of those species may die quickly from major damage.

Oaks vs. People. Bur oaks grow native along river valleys in North Dakota. These wooded areas are often sought as prime home building sites.
On such sites, the oaks frequently begin to decline shortly after
new construction. Even so minor a disturbance as changing underbrush into lawn, or water drainage changes from installation of a septic system may send oaks into a slow, irreversible decline. Very careful planning and management are necessary if oak woodland is to be preserved around a new home. Many prospective home buyers may find the needed protection is too costly or forces unacceptable design requirements.

Control: Protect tree **root systems**, not just the trunk, during construction. Prevent heavy equipment or traffic from travelling near trees. If this is unavoidable, aerate the soil immediately following such activity. Do not allow utility trenching near trees.

Insist upon written guarantees by contractors working near valuable trees. If major root damage to large trees is unavoidable, consider removing the tree and replanting. Often the savings by this procedure will more than pay for specimen size replacements. Do not pave over tree root systems. Roots need air to live!

If tree roots are damaged, careful pruning to balance top and roots can sometimes help the tree survive. Obtain the help of a professional arborist. Your city forester may recommend someone or offer direct assistance.

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Figure 10 - D. S. Welch
Figure 20A - Robert Heintz
Figure 20B - V. D. Pederson
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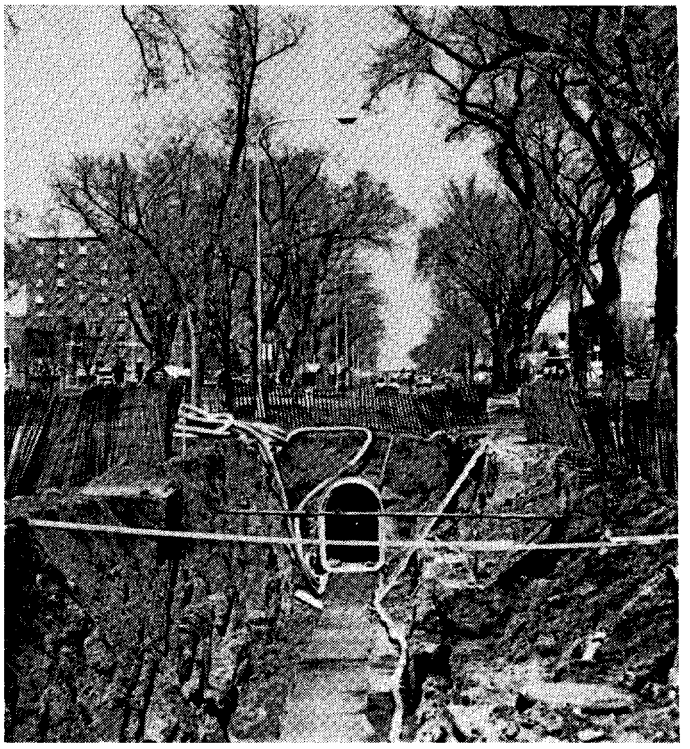

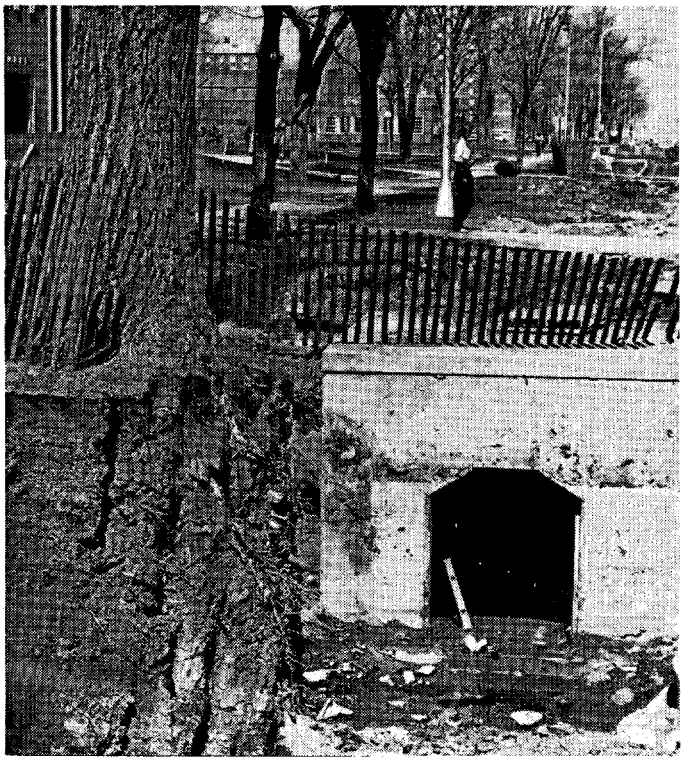

Figure 21.
Root injury from construction damage.

A. Major disturbance of adjacent trees.

B. The tree on the left has lost more than half of its root system.

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