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Ash Pests

A Guide to Major Insects, Diseases, Air Pollution Injury, and Chemical Injury

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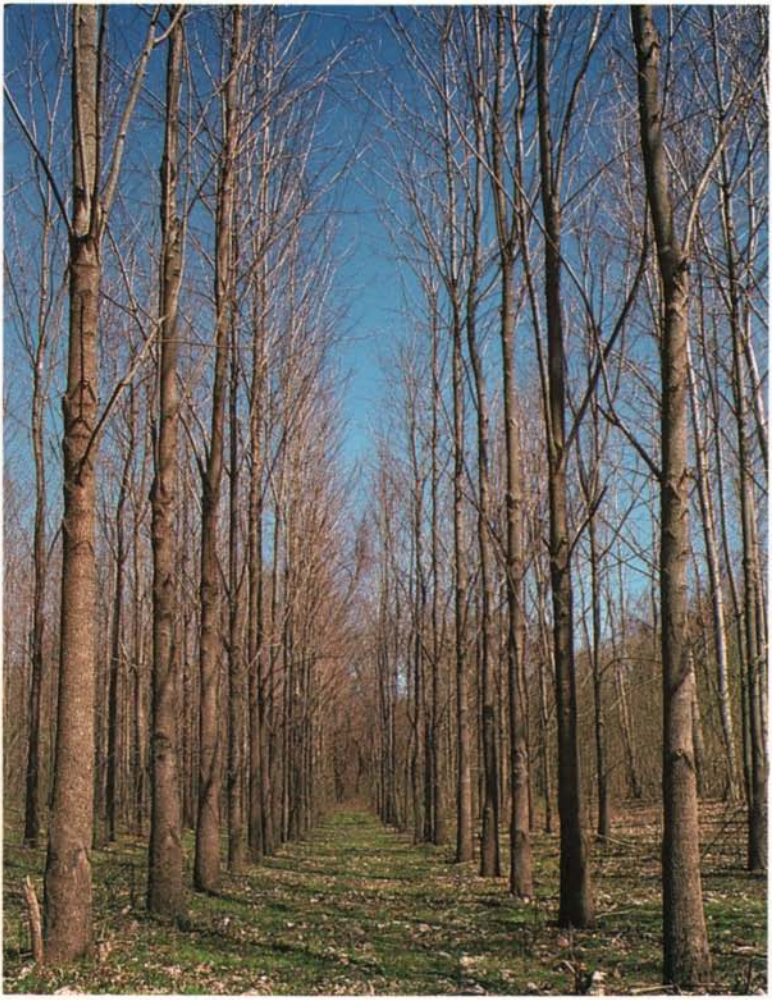

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CONTENTS

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INTRODUCTION

The ashes (*Fraxinus* spp.) are one of our more valuable hardwood resources—some 275 million board feet of ash lumber are sawn annually in the United States. White ash (*F. americana* L.) and green ash (*F. pennsylvanica* Marsh.), widely distributed throughout the Eastern United States and southern Canada, are the two most important species. Black ash (*F. nigra* Marsh.) is an important timber species in the Northeastern United States and southeastern Canada. Ash wood—tough, strong, and resistant to shock—is used for handles, oars, baseball bats, and furniture. Green, white, and black ashes grow best on fertile, moist, well-drained soils. But green ash, the most adaptable of the ashes, grows naturally on a wide range of sites from clay soils flooded up to 40 percent of the time to sandy, dry, harsh sites. Because of its hardiness, adaptability, and drought tolerance, green ash is used widely as an ornamental, in shelterbelts of the Great Plains, and for revegetation of strip-mining spoil banks. Green and white ashes are among only a few hardwood species being used to establish commercial timber plantations.

Insects, diseases, and pollutants are continuing problems for the ashes, but few actually threaten their widespread use. Disease, simply stated, is a condition of abnormal growth resulting from infection by a biotic agent (fungus, bacterium, or virus), or induced by an abiotic stress such as drought or air pollution. Fungi are the most com-

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mon causes of diseases of trees. Diminished growth and vigor, brought on by one or more biotic or abiotic factors, are perhaps the most serious problems of white ash. Wood boring insects, the most damaging pests of green ash, have damaged shelterbelt plantings in the Great Plains and caused considerable degrade losses in logs and lumber in the South. An estimated one-third of the ash trees larger than pole size contain some heartrot. Seed insects sometimes destroy up to 90 percent of the seed crop. Insects and diseases that destroy foliage can be disfiguring and cause growth loss, but seldom cause widespread damage. Because the gypsy moth, *Lymantria dispar* (L.), rarely feeds on ashes, ash species are often favored for planting in both forest and urban settings in the Northeastern States.

Cultural practices that maintain and promote tree health are encouraged to minimize losses. Control measures are not always feasible or needed for some ash pests covered in this guide, especially when light infestations or infections occur. The best procedure in these cases is to prevent problems by promoting and maintaining healthy trees. To this end, some recommendations are provided in the back of this guide in a section called "Maintaining Tree Health." However, chemical controls may become necessary as a last resort when all else fails.

This booklet will help nursery workers, resource managers, pest control personnel, and homeowners to prevent, identify, and control ash pests. The major insect and disease pests of ashes in the Eastern United States are emphasized. Descriptions and illustrations of the pests and their damage are provided to aid in identification. Brief notes are given on their biology and control to aid in assessing damage and making control decisions. Lists of chemical controls are provided, but recommendations are subject to change as certain compounds are discontinued and new materials approved. The chemical control section (tear sheet) in this booket can be removed and discarded when outdated as indicated by registered uses on pesticide labels. For further information on pesticides or additional assistance with ash pests, contact your State forester, county extension agent, or the nearest office of the USDA Forest Service, State and Private Forestry, Forest Pest Management.

Blackheaded Ash Sawfly, *Tethida barda* (Say)
Brownheaded Ash Sawfly, *Tomostethus multicinctus* (Rohwer)
Spiny Ash Sawfly, *Eupareophora parca* (Cresson)

Importance.—The ash sawflies are widely distributed throughout eastern North America and westward to the Great Plains. Young trees in new plantations and ornamental plantings seem particularly susceptible to defoliation.

Identifying the Insects.—Larvae of the blackheaded (fig. 1a) and brownheaded ash sawflies have greenish- to yellowish-white bodies. The spiny ash sawfly larvae (fig. 1b) have dark heads and gray bodies with numerous forked, dark spines. Larvae of all these species are about 16 to 19 mm long at maturity. Adults are typical sawflies, with mostly black bodies marked with red and white, and measure 6 to 8 mm in length.

Identifying the Injury.—The larvae feed gregariously in groups of 4 to 20, often lined up in rows feeding side by side. Young larvae chew holes in the leaflets, and older larvae eat entire leaflets. Heavily infested young trees may be completely defoliated in 1 to 2 weeks. Older trees may be so ragged that most of the leaves drop prematurely.

Biology.—In the spring, adults lay eggs in slits cut along the outer margins of young leaflets. Larvae feed and mature in early to mid-May in the South, later in the North. When mature, they drop to the ground where they make earthen cocoons in the soil and spend the summer, fall, and winter. In the spring, larvae pupate and emerge as adults to begin the cycle again. There is one generation per year.

Control.—Natural enemies usually keep sawfly densities low. Insecticides are effective in young plantations and ornamental plantings when severe infestations occur.

Figure 1.—*(a) Blackheaded ash sawfly larvae; (b) spiny ash sawfly larvae.*

Ash Sphinx, *Manduca jasminearum* (Guerin)
Great Ash Sphinx, *Sphinx chersis* (Hübner)
Waved Sphinx, *Ceratomia undulosa* (Walker)

Importance.—Sphinx larvae are seldom serious pests, but they are readily noticed because they are large and ornate caterpillars. All three species occur in the Eastern United States. The great ash sphinx ranges from coast to coast and has been known to concentrate locally on clumps of saplings, young trees, and sprouts.

Identifying the Insects (fig. 2a).—Sphinx larvae (hornworms) become quite large, reaching 75 mm in length. They have a distinctive horn-shaped spine on their distal end. Color markings are mostly pale green, usually with diagonal yellow or white markings. Adults are large moths with stout, spindle-shaped bodies; wings are narrow and brown or gray with dark and light bands. They are very strong fliers and are commonly known as hawk moths or hummingbird moths.

Identifying the Injury (fig. 2b)—Larvae typically consume the entire blade of tender leaves; midribs and major veins may be left on older leaves. Feeding begins and is most noticeable on the young leaves of terminals and branch ends and progresses toward the older foliage.

Biology.—Adults emerge during May and June and lay eggs on the foliage. Larvae may be found feeding from June to September. Mature larvae burrow into the soil to pupate. There are two generations per year in the South and only one in the North. Overwintering occurs in the pupal stage in the soil.

Control.—Natural enemies usually keep hornworm populations in check. Insecticides are rarely needed to protect seedlings and small trees.

Figure 2.—*(a) Sphinx larva (hornworm); (b) feeding injury on young sapling.*

Ash Plant Bugs, *Tropidosteptes* spp.

Importance.—Three species of ash plant bugs, *Tropidosteptes amoenus* Reuter, *T. tricolor* Van Duzee, and *T. cardinalis* Uhler, are mainly eastern species occurring west to Texas and the Great Plains; whereas two, *T. illitus* Van Duzee an *T. pacificus* Van Duzee, are western species. They suck the juices from buds, leaves, seeds, and shoots, causing distortion and premature shedding.

Identifying the Insects (fig. 3a).—Adults are elongate-oval, soft bodied, 3 to 6 mm long, with piercing-sucking mouthparts. They vary in color by species from black and white, to red and black, to light or dark brown. Nymphs are smaller than adults and are wingless.

Identifying the Injury.—Initial injury is caused mainly by the nymphs, which feed on the opening buds and new leaves. Later instars feed on leaves, flowers, and seeds. Concentrated feeding on buds and small expanding leaves causes them to become discolored, distorted, and stunted (fig. 3b). Feeding on older leaves causes stippling with black excrement spots (fig. 3c).

Biology.—Ash plant bugs overwinter as eggs laid in the thin bark of twigs. In the spring, these eggs hatch as the buds are opening. Nymphs feed mostly on the undersides of leaves and take 4 to 5 weeks to reach the adult stage. First generation adults begin the cycle again by laying their eggs mainly on the midribs of leaves. Typically, two broods are produced each year, although *T. illitus* produces only one.

Control.—Dormant oil sprays have been used during the winter months to kill the eggs. Insecticides can be used to control nymphs and adults in the spring.

Figure 3.—*(a) Adult ash plant bug* (Tropidosteptes cardinalis); *(b) injury to young expanding leaves; (c) stippling injury to full-grown leaves.*

Woolly Ash Aphid, *Prociphilus fraxinifolii* (Riley)

Importance.—This aphid occurs in the Eastern United States and west to Colorado. Heavy aphid infestations cause premature defoliation and stunt growth. The distorted foliage, along with accompanying honeydew and sooty mold, mar the beauty of ornamentals and make nursery plants unsalable.

Identifying the Insects (fig. 4a).—Aphids are 2.0 to 2.5 mm long, soft bodied, and pear shaped to globular, with a pair of tubes projecting from the abdomen. They are yellowish green to pale yellow with brown head and legs. Both winged and wingless forms occur. White, waxy secretions often cover the aphids, giving them a "woolly" appearance.

Identifying the Injury.—Aphids suck the sap from the undersides of tender, developing leaves of terminals and branch tips (fig. 4b). Feeding causes leaves to curl downward (fig. 4c). Unfolding the tightly curled leaves will reveal clusters of aphids. Heavily infested leaves may drop prematurely. A whitish, sticky honeydew produced by the aphids frequently coats the foliage and supports the growth of black, sooty mold.

Biology.—Overwintering occurs as eggs in bark crevices. The eggs hatch in the spring into wingless females that reproduce without mating. Several generations are produced each year. During fall, winged adults deposit the overwintering eggs. The largest populations are usually present during early summer.

Control.—Natural enemies routinely keep most aphid populations under control, but insecticides may be needed to protect nursery stock and ornamentals.

Figure 4.—*(a) Closeup of aphids under curled leaf; (b) heavily infested ash terminal; (c) heavily curled leaves caused by aphids.*

Ash Borer (terminal borer), *Podosesia syringae* (Harris)

Importance.—The ash borer is found throughout eastern North America. Spring feeding on tender shoots causes mortality of terminals resulting in forked trunks. When plantations are established to produce sawlogs, forked or deformed trunks are unacceptable losses. (This insect is also covered as a trunk pest in the insect borer section.)

Identifying the Insect.—Tiny larvae found burrowing in terminals are white to yellowish with the dark gut visible. Larvae vary from 1.5 to 5.0 mm in length. After vacating the shoots, they feed elsewhere on the trunk and branches and may reach 34 mm in length. Adults are brown to reddish clearwing moths with a wingspan of 25 to 38 mm.

Identifying the Injury (fig. 5a).—The earliest symptom is a sudden wilting of succulent green shoots, which become shriveled and dark within 4 to 8 days (fig. 5b). Tunnels are typically 1 to 3 cm long before the shoot is vacated. It takes less than 1 month for the terminal to wilt, darken, shrivel, die, and break away, often resulting in forked stems in new growth (fig. 5c).

Biology.—Adult moths begin emerging in March in the South and oviposit on the shoots and bark. Newly hatched larvae tunnel into the succulent shoots during April and May. In the South, shoot injury peaks by mid-May, declines in late May, and ceases by early June. Young larvae are present in the shoots for only 2 to 3 weeks; then they vacate the galleries and become trunk borers.

Control.—Natural enemies help reduce borer populations. Insecticides may be necessary in new plantings, especially those surrounded by heavily infested ashes.

Figure 5.—*(a) Early symptoms of ash borer infested terminal; (b) terminal killed by ash borer; (c) fork resulting from killed terminal.*

European Fruit Lecanium, *Parthenolecanium corni* (Bouché)
Oystershell Scale, *Lepidosaphes ulmi* (L.)
White Peach Scale, *Pseudaulacaspis pentagona* (Targioni-Tozzetti)

Importance.—Scale insects are common pests of ashes and are distributed throughout the United States. These insects suck the sap from plants, weakening them and making them susceptible to other pests. Scales often kill branches and occasionally individual trees.

Identifying the Insects.—Scale insects appear as protrusions on the branches and twigs. Mature oystershell scales are 3 mm long, brownish to purplish gray, narrow, and rounded toward the rear with concentric bands (fig. 6a). White peach scales are 1.5 mm wide, circular, and white to gray or yellowish (fig. 6b). European fruit lecaniums are 4.7 mm wide, circular, reddish to dark brown, and often covered with white powder (fig. 6c).

Identifying the Injury.—Crown dieback is the principal symptom of severe infestations. Honeydew may be produced, which supports a black, sooty mold that turns leaves and branches black. Heavily infested plants produce pale foliage and few new shoots and exhibit twig and branch dieback.

Biology.—Females lay eggs under waxy domes. The newly hatched nymphs, called crawlers, crawl to new sites on the bark and begin feeding. The oystershell scale overwinters in the egg stage. Two generations occur in Maryland, where crawlers are present in May and June and again in mid-July. The white peach scale has four generations per year in Florida and three in Maryland. The crawlers are present in May, July, late August, and early September. The European fruit lecanium produces one generation per year.

Control.—Contact insecticides are effective when timed with the appearance of crawlers. Dormant oil sprays will kill overwintering scales.

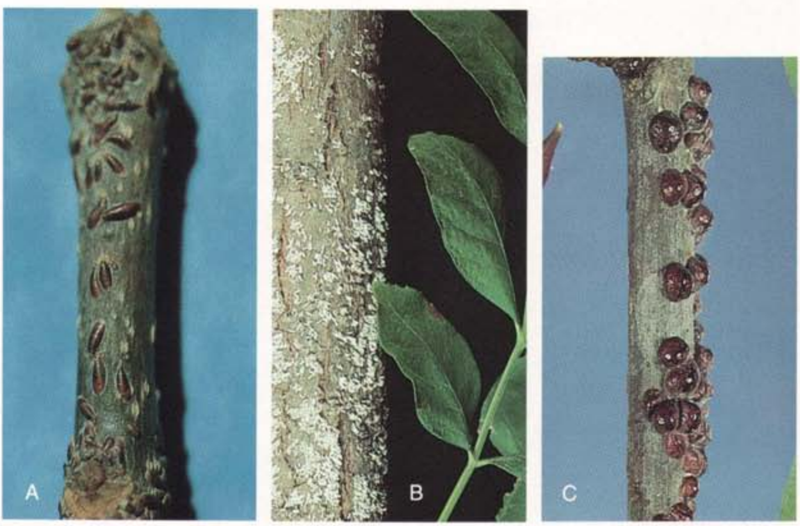

Figure 6.—*(a) Oystershell scales; (b) white peach scales; (c) European fruit lecaniums.*

Flatid Planthoppers: *Acanalonia conica* (Say), *Anormenis septentrionalis* (Spinola), *Metcalfa pruinosa* (Say)

Importance.—Flatid planthoppers occur throughout the Eastern United States, west to the Great Plains; one species, *Metcalfa pruinosa,* ranges from coast to coast. Planthoppers suck the sap from small diameter stems, but damage is usually minor. Oviposition injuries sometimes kill seedlings.

Identifying the Insects (fig. 7a).—Adult flatid planthoppers are pale or yellowish green to brown or black but are usually covered by white, powdery wax, which imparts a whitish-gray or bluish-green appearance. They have large prominent wings held at an acute, rooflike angle over the body and range from 6 to 13 mm long. Nymphs are wingless, slightly elongate, slightly flattened, and partially to completely covered with filaments of white, woollike wax (fig. 7b).

Identifying the Injury.—Feeding by large populations causes seedlings and terminals of older plants to wilt. Although sap-feeding may slow plant growth, it rarely causes widespread dieback. However, clusters of oviposition punctures along stems may cause mortality of seedlings and shoot dieback on older plants.

Biology.—Overwintering eggs hatch during the spring. Nymphs feed singly or in clusters on tender shoots. Adult flatid planthoppers appear by June or July and are present until fall. They deposit their eggs in a series of short slits in the bark. There is only one generation per year.

Control.—Natural enemies help keep populations in check. On young plants, pruning and destroying shoots that contain oviposition punctures (before the eggs are able to hatch) provides some control.

Figure 7.—*(a) Adult flatid planthoppers; (b) flatid planthopper nymphs.*

Ash Borer (trunk borer), *Podosesia syringae* (Harris)

Importance.—This borer is a destructive pest throughout eastern North America. Trunk infestation rates of 50 percent are common in shelterbelts of the Great Plains. In the South, trees intended for wood products are degraded and reduced in value. Shade and ornamental trees may be scarred, seriously weakened, or killed.

Identifying the Insect.—Adults are clearwing moths that mimic paper wasps in appearance and flight. The wingspan of the moth is about 25 mm. The wings and body are brownish black, and the legs are marked with black, orange, and yellow. Larvae are white, except for an amber-colored head and thoracic shield, and are about 25 to 34 mm long at maturity.

Identifying the Injury (fig. 8a).—The first evidence of attack is sap mixed with fine frass oozing from small holes in the bark. Later, the frass is extruded in small clumps. Circular adult exit holes, often with pupal skins protruding, are found above the irregularly shaped entrance holes. Infestation is greatest in the lower trunk. Lumber sawn from infested trees may exhibit numerous dark-stained, pencil-sized holes (fig. 8b).

Biology.—Adults begin emerging during February in Florida and during July in the North. Emergence is completed by the end of July. There is a single brood per year. Eggs, deposited singly or in small clusters in bark crevices, hatch in 11 days. Young larvae mine in the phloem and cambium, then excavate galleries 7.5 to 13.0 cm long in the wood.

Control.—Natural enemies, wound prevention, brood tree removal, burlap trunk wraps, and insecticides help to reduce populations. Pheromone traps are used to monitor moth flights in order to time insecticide applications.

Figure 8.—*(a) Ash borer gallery, entrance and exit holes, and bark scars of entrance and exit holes; (b) ash borer defects in lumber.*

Banded Ash Clearwing, *Podosesia aureocincta* Purrington & Nielson

Importance.—This clearwing is similar in distribution and appearance to the ash borer and causes similar damage to boles and branches. Its populations are smaller and more scattered than those of the ash borer.

Identifying the Insect (fig. 9a).—Adult clearwings are slightly larger than adult ash borers and have forewings that are violet brown and mostly dark. The body is brownish black, but abdominal segment 4 is bordered at the rear with a distinct, narrow, upward-tapering, bright orange-yellow band. The larvae can be distinguished from ash borer larvae because they have fewer crochets on the abdominal legs (12 to 16 per row vs. 16 to 20 per row, respectively).

Identifying the Injury (fig. 9b).—Injury is similar to that of the ash borer, but the seasonal occurrence is markedly different. Females lay eggs in late summer. Soon after, and continuing into the fall, larvae begin feeding, causing sap to ooze and fine frass to be extruded from attack sites. The next spring and summer, the frass becomes coarse and granular and is extruded in small clumps (fig. 9c). Pupal skins may be found protruding from exit holes in the bark from late summer to winter.

Biology.—Adults emerge from August to December, whereas those of the ash borer emerge during spring and summer. Emergence peaks from mid-September to early October. Larvae overwinter as second instars within their mines in the phloem-cambium area.

Control.—Woodpeckers, other natural enemies, and good cultural practices help to reduce populations. Insecticides must be applied in late summer and fall to kill newly hatched larvae.

Figure 9.—*(a) Mating pair of banded ash clearwings; (b) partially completed gallery; (c) entrance hole in bark with frass clumps.*

Carpenterworm, *Prionoxystus robiniae* (Peck)

Importance.—Carpenterworms, widely distributed through the United States and southern Canada, bore into trunks and branches. For years, they were recognized mainly as pests of shade, ornamental, and shelterbelt trees, but their impact through log and lumber defects is even more important.

Identifying the Insect (fig. 10a).—Young larvae are reddish pink. Mature larvae are creamy white with a shiny, dark-brown head and black mandibles, and are 50 to 75 mm long. Adults are large, grayish moths with black and gray mottled wings; males have an orange spot on their hind wing.

Identifying the Injury.—The earliest signs of attack are sap spots with fine boring dust. Later, frass is discharged from entrance holes. Larvae chew cavelike burrows 50 mm in diameter (fig. 10b) and galleries 12 to 22 cm long in the wood (fig. 10c). Oval to irregularly shaped bark scars are evident. Damage in sawn lumber appears as pockets of ingrown bark and stained holes 12 mm in diameter.

Biology.—Adult moths appear from April to June and deposit 400 to 800 eggs in bark crevices. Eggs hatch in 10 to 12 days, and young larvae tunnel into the bark and wood. Pupation occurs within the tunnel and lasts 3 weeks. A life cycle requires 1 to 2 years in the South, and 2 to 4 years in the North.

Control.—Open-grown trees are most susceptible, thus stands should be kept well stocked. Brood trees should be identified and removed. Injuries during logging should be prevented or minimized. Natural enemies provide some help. Insecticides can protect ornamental trees.

Figure 10.—*(a) Carpenterworm larva; (b) large, cave-type burrow under bark; (c) gallery in bole.*

Banded Ash Borer, *Neoclytus caprea* (Say)
Redheaded Ash Borer, *Neoclytus acuminatus* (Fabricius)

Importance.—These borers infest weakened, dying, and recently dead ash trees, but are most destructive to recently cut sawlogs. They occur throughout most of the United States, but are most common in the East.

Identifying the Insects (fig. 11a).—Adults of both species are elongate, tapered in form, and vary from 4 to 18 mm in length. The redheaded ash borer is reddish with yellow bands; the banded ash borer is black with yellowish-white bands. Larvae of both species are creamy white, short, robust, and 10 to 22 mm long.

Identifying the Injury (fig. 11b).—Round adult exit holes in the bark and wood and mines under the bark are evidence of infestation (fig. 11c). The principal injury is from larval tunnels in the sapwood; the oval tunnels are tightly packed with frass. Injury to recently felled trees and logs is often confined to the shaded bottom half.

Biology.—Adults of the redheaded ash borer emerge from May to August in the North and from February to November in the South. Eggs, deposited under the bark, hatch in 1 week. Larvae penetrate the sapwood to feed and overwinter in their tunnels. There are two to three generations per year in the South and one to two in the North. The banded ash borer has one generation per year.

Control.—Keeping ornamentals healthy will help prevent infestation. Sawlogs may become infested within 20 days of felling during the summer and must be processed promptly.

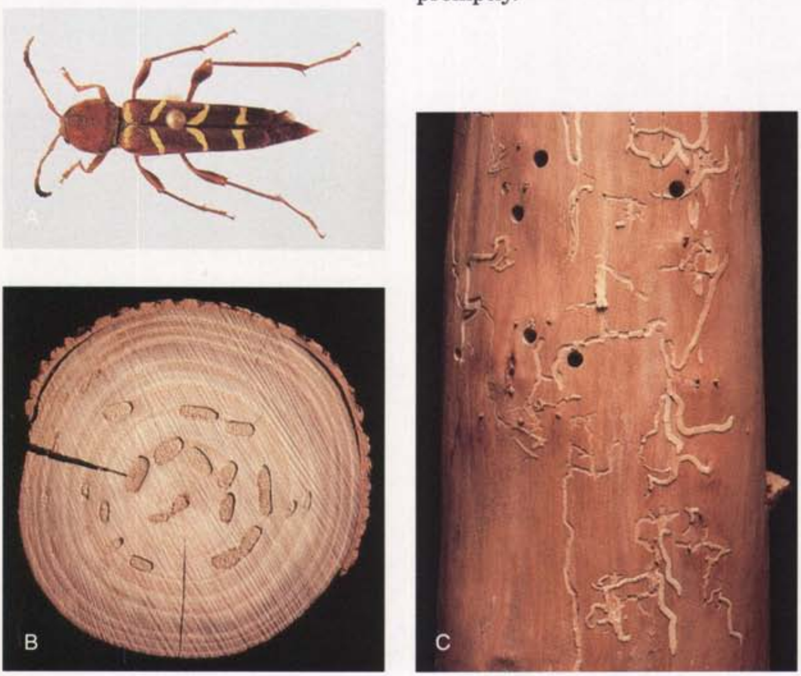

Figure 11.—*(a) Adult of redheaded ash borer; (b) cross section of oval, frass-packed tunnels; (c) larval mines and exit holes on sapwood surface.*

Ash Cambium Miner, *Phytobia* sp.

Importance.—Maggots of this fly mine in the cambium of tree boles and roots in the Eastern United States. They cause defects consisting of small, light to dark streaks evident in tangential cuts of wood or specks known as pith ray flecks, worm tracks, or glassworms as seen in cross-sectional cuts. Such defects cause quality degrade when the wood is used for veneer, cabinets, baseball bats, or tool handles.

Identifying the Insects (fig. 12a).—The larvae are long, narrow maggots, somewhat laterally flattened, and measure about 25 mm long when fully grown. Adults look somewhat like small, hairy house flies.

Identifying the Injury (fig. 12b).—The maggots make long threadlike mines in the cambium of branches, boles, and roots. Mines are most common in the basal 90 cm of the trunk and in the roots within 1.5 m of the bole (fig. 12c). Mining in living trees is detectable only by removing the bark. In lumber and veneer, mines appear as zigzag tracks lighter or slightly darker than the natural wood.

Biology.—Eggs are laid in small twigs. Maggots mine in the cambium and inner bark down the stem and into the roots. Second-instar maggots overwinter in the roots. Full-grown maggots exit through the bark and form puparia in the soil. In the North, pupation occurs in May and June, whereas in Mississippi, it occurs from February to April. The life cycle is completed in 1 year.

Control.—Dead maggots have been found in their mines following unusually cold winters. Other natural controls are unknown, and direct controls have not been investigated.

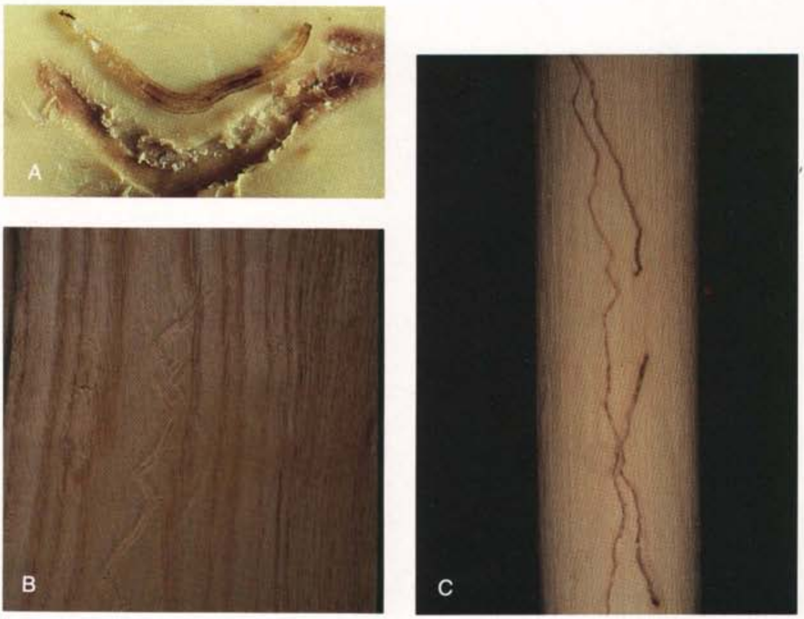

Figure 12.—*(a) Ash cambium miner larva; (b) zigzag glassworm tracks in ash veneer; (c) threadlike mines on sapwood surface.*

Eastern Ash Bark Beetle, *Hylesinus aculeatus* (Say)
Northern Ash Bark Beetle, *Hylesinus criddlei* Swaine
White-Banded Ash Bark Beetle, *Hylesinus fasciatus* (LeConte)

Importance.—One or more species of ash bark beetles are found in any given region of the United States. They attack and breed in weakened, felled, and storm-damaged trees; only occasionally do they attack healthy trees. On some sites of the dry Great Plains, the western ash bark beetle causes severe branch- and top-kill.

Identifying the Insects (fig. 13a).—Adult beetles are slightly elongate, cylindrical, and 2.0 to 3.4 mm long. Dense areas of light- and dark-colored scales produce mixed bands or spots. Larvae are legless grubs with a white, slightly curved body and a light-brown head (fig. 13b).

Identifying the Injury (fig. 13c).—Injury to trees results from tunneling in the inner bark and surface of the sapwood. The large egg gallery has two branches extending across the wood grain in opposite directions from the bark entrance. Larval galleries radiate outward from the egg gallery. The bark may be peppered with 1-mm, round exit holes (fig. 13d).

Biology.—Overwintering adults fly to susceptible trees in the spring where they burrow into the bark and begin laying eggs. Larvae pupate in small cells at the end of their tunnels. New adults burrow out to the bark surface. There are one to two generations per year. Adults overwinter in short feeding tunnels in the bark of living or recently felled trees.

Control.—Direct controls are rarely needed. Cultural controls include debarking felled trees and logs and/or burning them to prevent brood emergence. To prevent attacks insecticides may be applied to the bark.

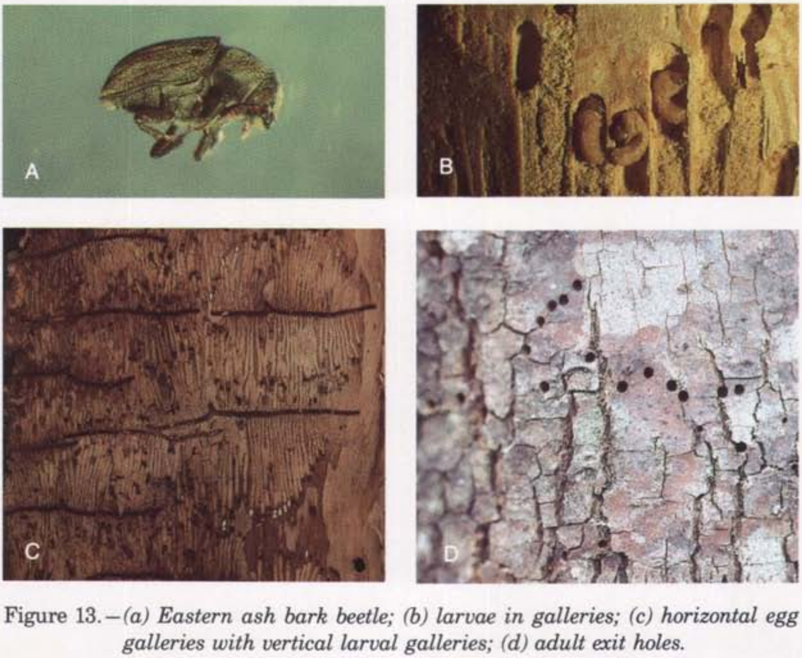

Figure 13.—*(a) Eastern ash bark beetle; (b) larvae in galleries; (c) horizontal egg galleries with vertical larval galleries; (d) adult exit holes.*

Ash Flowergall Mite, *Aceria fraxiniflora* Felt

Importance.—This eriophyid mite attacks male flower clusters, turning them into masses of lumpy, distorted galls. Infestations do little damage to trees, but the galls are unsightly and may markedly detract from the appearance of ornamentals. The mite is distributed throughout the United States and southern Canada.

Identifying the Mite.—The mites are minute, about 0.5 mm long, soft bodied, wormlike or spindle shaped, and white to straw colored. They are so small as to be largely invisible to the unaided eye and are frequently overlooked, even with a 10x magnifier.

Identifying the Injury (fig. 14).—Feeding by the mites on the male flower clusters causes swelling of the tissues. Flower stems elongate, pedicles of individual flowers often fuse, and all parts curl and twist. Infested flower clusters become irregularly branched, fringed, gall-like masses. Galls are initially green but darken and become black later in the season, and many persist until the following spring.

Biology.—In the spring, overwintering females move to the developing flowers to feed and deposit eggs. Nymphs live and feed in protected crevices of the gall tissue. There are several generations during the spring and summer. In the fall, fertilized females move to bark crevices and beneath bud scales to overwinter.

Control.—High-valued trees can be sprayed in the early spring as soon as they begin to flower.

Figure 14.—*Male flower clusters converted to gall-like masses by ash flower gall mites.*

Ash Seed Weevils, *Lignyodes* spp.

Importance.—Three ash seed weevils, *Lignyodes bischoffi* (Blatchley), *L. helvolus* (LeConte), and *L. horridulus* (Casey), occur throughout the United States and Canada. These weevils feed on the seeds of ashes and lilac. Over 60 percent of the ash seeds in the Northeastern States and up to 95 percent in the Great Plains may be destroyed.

Identifying the Insects (fig. 15a).—Adults are elongate-oval and 2.3 to 4.0 mm long. The pronotum is narrower than the base of the elytra, and the snout is curled with elbowed antennae. The pronotum and elytra are covered with brown to yellow scales. Color patterns distinguish the species. Larvae are white and legless with a curved body and brown head (fig. 15b).

Identifying the Injury.—Infested seeds are difficult to distinguish with the naked eye. With magnification, small, raised, puncture marks partially covered with dark excrement can be observed on the seedcoat (fig. 15c). Cutting open the seed will reveal the feeding larvae (fig. 15d). Small oval to irregular holes are left in seeds by emerging larvae.

Biology.—The weevils overwinter as larvae in the soil or in fallen seeds. Pupation occurs in the soil during spring and summer and lasts about 12 days. Adults emerge during July and August and are present until autumn. Females deposit eggs singly within the seed and seal the openings with excrement. Eggs hatch in 2 days, and the larvae completely consume the seed contents. Mature larvae exit the seed during fall, winter, or spring and burrow into the soil to pupate. There is one generation per year.

Control.—Natural controls keep most populations in check. Direct controls are rarely justified.

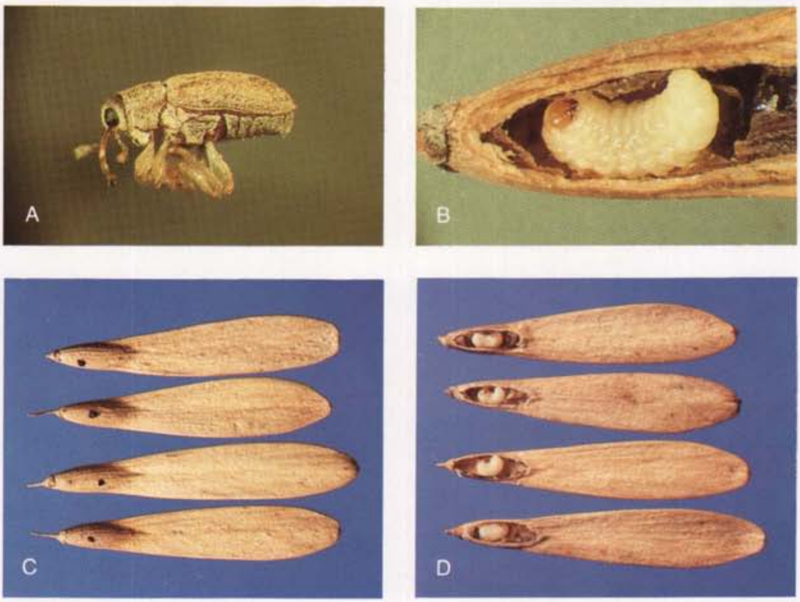

Figure 15.—*(a) Adult ash seed weevil; (b) ash seed weevil larva; (c) infested ash seeds with egg punctures; (d) seeds cut open to expose larvae.*

Leafroll Midges

Pest.—Leafroll midges, *Dasineura* spp.; larvae are small, white maggots 2 to 3 mm long; occur in the Eastern United States; produce one to two generations per year.

Injury.—Several tiny maggots feed together in young, unfolded leaves of ashes in early spring, etching the tender epidermis and keeping the leaves from unfolding; damaged leaves roll, curl, distort, and may fall off (fig. 16a).

Prevention and Control.—Natural control is usually adequate; trees should be kept in vigorous condition; direct controls are rarely needed.

Leaf Beetle

Pest.—Leaf beetle, *Octotoma plicatula* (Fab.); a black, wedge-shaped beetle 4 to 5 mm long, with a distinctive, irregular design of ridges on its wing covers; adults are active from early May through August.

Injury.—Long, narrow patches of epidermis about 2 mm wide and 4 to 10 mm long are eaten from the undersides of leaves (fig. 16b). Heavily damaged leaves turn brown and drop prematurely in late summer.

Prevention and Control.—Trees should be kept in vigorous condition; direct controls are rarely needed.

Spring Cankerworm

Pest.—Spring cankerworm, *Paleacrita vernata* (Peck); caterpillars are typical loopers; brown to black with yellow stripes (fig. 16c); occur in the Eastern United States and southern Canada; 25 to 48 mm long; produce one generation per year.

Injury.—In the spring, young larvae eat holes in the leaves; later the whole leaf is eaten except for the midrib and major veins; defoliation stresses the trees.

Prevention and Control.—Sticky bands around tree trunks will trap the wingless females; chemical or biological controls are occasionally needed.

Fall Webworm

Pest.—Fall webworm, *Hyphantria cunea* (Drury); mature larvae are 25 mm long, pale yellow to greenish and with hairy, red or black heads; occurs throughout the United States and southern Canada; produces one to four generations per year.

Injury.—Caterpillars make webbed nests around leaves at branch ends, living and feeding in groups inside the nests; populations and webbed nests are most abundant in late summer and fall (fig. 16d).

Prevention and Control.—Natural enemies are usually effective; webbed nests can be pruned from small trees; chemical or biological controls may be needed.

Forest Tent Caterpillar

Pest.—Forest tent caterpillar, *Malacosoma disstria* Hübner; caterpillars have a dorsal row of keyhole-shaped, white spots bordered by pale-bluish lines (fig. 16e); mature larvae are 50 mm long; occurs throughout the United States and Canada; produces one generation per year.

Injury.—Caterpillars begin feeding on ash foliage as it emerges in early spring; first noticeable signs of attack are sparse crowns and falling frass; caterpillars feed for 4 to 6 weeks.

Prevention and Control.—Parasites, predators, and diseases keep most infestations in check; chemical and biological controls may be needed.

Ashleaf Gall Mite

Pest.—Ashleaf gall mite, *Aceria chrondriphora* Keifer; mites are elongate, spindle shaped, and soft bodied; hardly visible to the naked eye; live inside leaf galls throughout the United States and southern Canada.

Injury.—The galls on the upper surface of leaves are greenish yellow, 2 to 3 mm in diameter (fig. 16f), reniform in shape, solitary but numerous, scattered along the lateral veins, and reduce esthetic value of trees.

Prevention and Control.—Natural controls are usually adequate; fallen leaves should be raked and destroyed; direct controls are rarely needed.

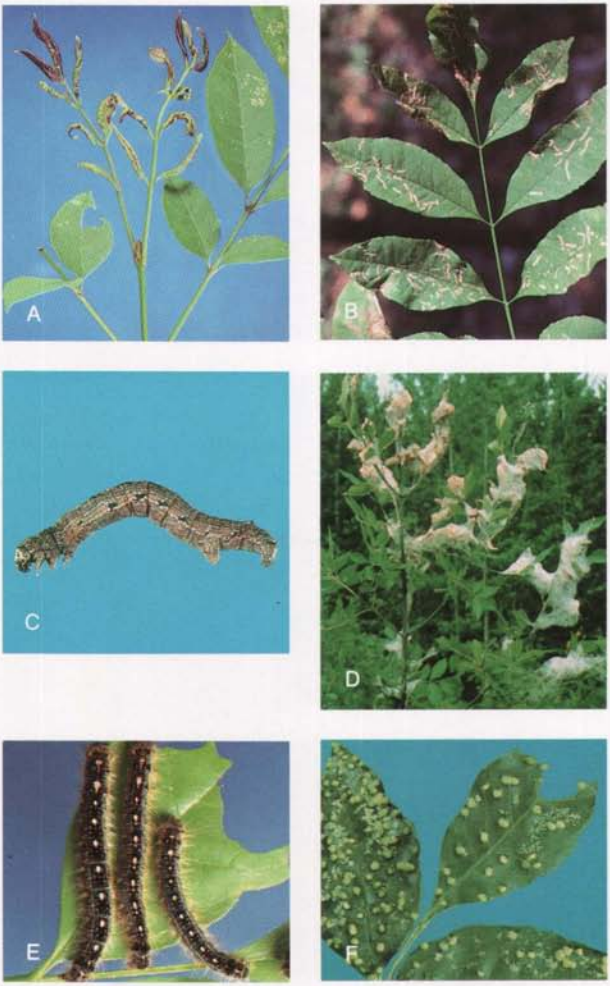

Figure 16.—*(a) Curled leaves from leafroll midge; (b) leaf beetle feeding symptoms; (c) spring cankerworm; (d) fall webworm tents in young ash; (e) forest tent caterpillars; (f) leaf galls caused by ashleaf gall mites.*

Damping-Off, *Cylindrocladium* spp., *Fusarium* spp., *Phytophthora* spp., *Pythium* spp., *Rhizoctonia* spp.

Importance.—Damping-off is the most important and widespread disease of ash seedlings in tree nurseries. The disease is most prevalent in cool, low-lying areas where standing water persists, in acidic soils, and under any conditions where seedling growth is poor. Seedling density may be reduced up to 25 percent or more when poor cultural practices are used.

Identifying the Disease.—Damping-off may prevent the emergence of seedlings from the soil as the seeds or hypocotyls are attacked. Seedlings attacked after emergence fall over because the hypocotyls are rotted at or below the soil line (fig. 17). Both types of damping-off result in reduced seedling survival causing nonuniform seedling sizes and densities.

Identifying the Fungi.—Many fungi prevalent in soils can cause damping-off. *Fusarium* spp., *Pythium* spp., and *Phytophthora* spp. are most active in cool, wet soils, whereas *Cylindrocladium* spp. and *Rhizoctonia* spp. are more common in warm, wet soils.

Biology.—The soil-borne fungi that cause damping-off of seedlings are able to survive in the soil in the absence of a host. All produce resistant spores or sclerotia that survive in the soil until root exudates stimulate their germination or growth, leading to the infection of seeds or seedlings.

Control.—Damping-off can be controlled with cultural practices. Seeds should be planted on well-drained sites or in raised beds at soil temperatures above 15 °C, avoiding dense stands. Nitrogen fertilizers should not be applied until seedlings are 6 weeks old. Soil acidity should be maintained at pH 6.0 or slightly above. Soil fumigation or seed treatment with fungicides is sometimes necessary for adequate control.

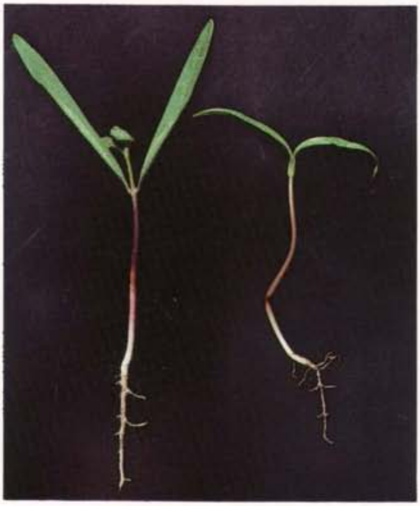

Figure 17.—*Ash seedlings with symptoms of postemergence damping-off.*

Anthracnose, *Gnomoniella fraxini* Redlin & Stack

Importance.—Ash anthracnose may be the most common foliar disease of ashes in the United States. It is most important in landscape and street-side plantings and in plantations, and is less important in natural forest stands.

Identifying the Disease.—Round to irregular blotches, greenish brown at first, but turning brown with age, appear along margins and midribs of leaflets (fig. 18a). Affected leaflets appear scorched and may curl and drop from the tree. Small cankers and dieback may occur on twigs of trees severely defoliated for several years. Numerous small, round lesions with gray centers and purple-brown margins (frogeye leaf spots) may develop late in the season (fig. 18b).

Identifying the Fungus.—Acervuli, colorless initially and darkening with age, can be found on leaflets shortly after infection. Acervuli are also common on previous-year petioles (fig. 18c) and twig cankers. Masses of dull-white, to pale-pink conidia may be seen exuding from mature acervuli. Black perithecia develop over winter on petioles, leaves, and twigs on the ground.

Biology.—Expanding leaflets and shoots are infected in the spring by rain-splashed conidia from acervuli on dead petioles remaining on trees from the previous year. Additional infections may augment the disease during the growing season. Anthracnose is favored by cool, wet, spring weather and a lack of air circulation around susceptible tissues.

Control.—Direct control is rarely needed.

Figure 18.—*(a) Shoot infected with anthracnose, some leaflets have already fallen; (b) frogeye leaf spots; (c) acervuli on previous-year petioles.*

Ash Rust, *Puccinia sparganioides* Ellis & Barth

Importance.—Ash rust attacks most ash species growing east of the Rocky Mountains. It is most severe near coastal areas where its alternate hosts, cord and marsh grasses (*Spartina* spp.), are abundant. Severe damage is infrequent since trees usually recover, although repeated infections have been reported to cause dieback and tree mortality.

Identifying the Disease.—From mid-April to mid-June, the upper surfaces of leaves develop yellow-orange spots, while chlorotic spots develop on petioles and current-year twigs (fig. 19a). Swelling of diseased tissues leads to distortion and necrosis of leaves, bending of petioles, and development of galls on twigs. Trees with severe infections appear scorched, and affected leaves often drop prematurely.

Identifying the Fungus.—Clusters of aecia containing orange-yellow aeciospores appear prominently on twigs, petioles, and lower surfaces of leaves (fig. 19b). Yellow uredinia develop on alternate hosts and are replaced in the fall by dark-colored telia.

Biology.—This fungus has five spore stages of which two must occur on alternate hosts for infection of ashes. In the spring, teliospores that overwintered on alternate grass hosts produce basidiospores that infect the current-year tissues of ashes, causing spermogonia and then aecia to develop. Aeciospores are blown to and infect alternate hosts on which uredinia develop in early summer. During the summer, urediniospores repeatedly infect cord or marsh grass. Uredinia eventually develop into brownish-black telia in the fall.

Control.—To control severe infections in valuable trees, fungicide sprays should be used at 2-week intervals in the spring starting at bud break.

Figure 19.—*(a) Multiple aecial infections on foliage; (b) aecia on twigs and petioles.*

Mycosphaerella Leaf Spots, *Mycosphaerella effigurata* (Schwein.) House, *Mycosphaerella fraxinicola* (Schwein.) House

Importance.—Leaf spots cause premature defoliation of ash seedlings, and forest and shade trees in North America. Mycosphaerella leaf spot, heretofore called "Piggotia leaf spot," is most common in nurseries. Infection by *Mycosphaerella fraxinicola,* previously called "Phyllostica leaf spot," is a problem in large trees.

Identifying the Disease.—Leaf spots caused by *M. effigurata* appear in June as flecklike, yellow spots, 1 to 3 mm in diameter, on upper leaf surfaces. Hundreds of flecks may occur on a single leaflet (fig. 20a, b). By late summer, dark asexual stromata give lower leaf surfaces a sooty appearance. Seedlings may defoliate prematurely near the end of the growing season. Initial leaf spots caused by *M. fraxinicola* are pale-green, irregular blotches, 5 to 15 mm in diameter (fig. 20c). Spots sometimes coalesce and entire leaflets may die. Trees may appear scorched due to necrotic blotches on foliage. Severe infections can result in premature defoliation.

Identifying the Fungus.—Both *M. effigurata* and *M. fraxinicola* have two asexual fruiting stages. Those of *M. effigurata* develop earlier in the growing season than those of *M. fraxinicola. Mycosphaerella fraxinicola* produces cylindrical, colorless conidia in contrast to the two-celled, colorless conidia of *M. effigurata*. Both species produce two-celled, colorless ascospores in pseudothecia that mature and overwinter in fallen leaves. Ascospores of *M. effigurata* are 1.5 to 2.0 times longer than those of *M. fraxinicola.*

Biology.—Ascospores dispersed by wind from fallen leaves initiate primary infections on new leaves in the spring. Wet weather increases the severity of the disease.

Control.—There is no practical control available for these leaf diseases.

Figure 20.—*(a)* Mycosphaerella effigurata *on white ash seedlings; (b)* M. effigurata *on green ash in nursery; (c) leaf spots caused by* M. fraxinicola.

Powdery Mildews, *Phyllactinia guttata* (Wallr.:Fr.) Lév and other species.

Importance.—Powdery mildews cause only minor damage to ashes in the Eastern United States. On shade and ornamental trees and seedlings, progression of the disease can reduce vigor, but it does not substantially reduce annual growth. Damage to forest trees is negligible.

Identifying the Disease.—Severe infections can cause distortion of tender, late season shoots, as well as chlorosis, foliar browning, and premature defoliation.

Identifying the Fungi.—Powdery mildews are easily identified by the white or light-colored, powdery fungal growth that develops on upper or lower leaf surfaces (fig. 21a, b). Identification of species is based on microscopic examination of cleistothecia, conidia, and conidiophores. Cleistothecia are minute, yellow to black, sexual fruiting structures usually found late in the season on the lower surface of leaflets. Cleistothecia of *P. guttata* have straight appendages with a bulbous base and asci that contain two spores.

Biology.—Powdery mildews are most prevalent where cool to warm, humid weather persists with little rainfall. Primary infection of ashes occurs by ascospores released from overwintered cleistothecia on fallen leaves. Conidia can cause repeated infections during the growing season.

Control.—No control is usually needed for this disease.

Figure 21.—*(a)* Powdery mildew infection on upper leaf surface; (b) infection on lower leaf surface.

Ash Yellows, Mycoplasmalike organisms (MLO's)

Importance.—Ash yellows causes substantial growth reduction, decline, and mortality of white ash in the Northeastern United States. Green ash appears to be more tolerant of ash yellows. Symptoms similar to those of ash yellows have been reported in Georgia and Louisiana. Trees of all ages and sizes in landscape plantings, hedgerows, and forests are susceptible.

Identifying the Disease (fig. 22a).—Symptoms vary with host susceptibility and disease progression, but in general, initial symptoms are reduced radial (fig. 22b) and shoot growth. Sustained infections can cause branch dieback, thin chlorotic crowns, epicormic sprouting, bark cracks, early fall coloration, and premature death. These decline symptoms, however, can develop from other causes. Witches' brooms (fig. 22c) are definitive, although inconsistent, symptoms of ash yellows.

Identifying the Pathogen.—Identification is based on finding MLO's in stained sections of phloem using a microscope. Tentative field diagnosis can be made by the presence of witches' brooms.

Biology.—Ash yellows is caused by MLO's that inhabit phloem tissue. MLO's are similar in nature to bacteria but lack cell walls. While infections are systemic, it is unclear how MLO's enter ash trees; insect vectors are one possibility. Infected white ash appears to be more susceptible to other stresses such as drought.

Control.—Merchantable white ash with ash yellows dieback should be harvested. Infected landscape trees without severe dieback may respond favorably to fertilization and irrigation.

Figure 22.—*(a) Crown thinning, dieback, and epicormic sprouting; (b) growth decline (12 annual rings are present between the arrow and the cambium); (c) witches' broom at base of white ash.*

Ash Dieback, Various causal agents

Importance.—White ash and green ash trees in forests, shelterbelts, and landscape plantings of the Northeastern and North Central United States are affected substantially by this malady.

Identifying the Disease (fig. 23a).—Symptoms of abnormal growth are similar to those described for ash yellows. Epicormic sprouts and witches' brooms, indicators of MLO infection, have been associated with ash dieback. Stem and branch cankers (fig. 23b) caused by various fungi often lead to progressive crown dieback.

Identifying the Causal Agents.—Decline of ashes in the absence of MLO infection is usually due to multiple biotic and abiotic agents. Drought may be the primary cause of dieback in many areas. A list of other possible causal agents includes at least three viruses (fig. 23c), two fungal pathogens (*Cytospora pruinosa* and *Fusicoccum* spp.), freeze damage, and air pollutants.

Biology.—The initial development of ash dieback frequently involves drought stress, which may be aggravated by freeze damage, or the presence of one or more opportunistic fungal pathogens or viruses. Stress induced by other agents may be worsened by MLO infectons in white or green ash.

Control.—In forests, sites should be carefully selected and species composition managed to avoid having mature ashes on droughty sites. Tree stress may be reduced in landscape plantings by fertilization and irrigation during dry weather.

Figure 23.—*(a) Dieback and thinning in white ash; (b) stem canker caused by* Cytospora pruinosa; *(c) ringspots caused by tobacco ringspot virus.*

Verticillium Wilt, *Verticillium albo-atrum* Reinke and Berthier and *Verticillium dahliae* Kleb

Importance.—This disease is prevalent in nurseries and landscape plantings of white and green ashes in the Northeastern and Midwestern United States. Rarely has it been described in forest stands.

Identifying the Disease (fig. 24a, b).—Sudden wilting of foliage on one or several branches is typically the earliest visible symptom. Leaves turn pale green to yellow and may appear scorched before falling, although green leaves may drop before they wilt. Additional symptoms include sparse foliage, stunted growth, and dieback. Infected sapwood often exhibits brown streaking, but this symptom is not always present. Trees with extensive wilt symptoms in much of the crowns will usually die before the end of the growing season.

Identifying the Fungus.—Fungal hyphae and conidia are visible with magnification in the conducting tissue of infected wood. Black microsclerotia or resting hyphae (15 to 100 μm in diameter) and the whorled (verticillate) arrangement of conidiophore branches can be seen in culture.

Biology.—*Verticillium* spp. survive periods of cold and drought by producing thick-walled microsclerotia, which may be dispersed in diseased plants and plant parts, eventually infesting the soil. Hyphae from microsclerotia penetrate ash roots growing next to them in the soil. The fungus also invades the host through wounds but spreads most rapidly when conidia move in the sap stream of conductive tissue. In this way, multiple infections can occur in large trees, eventually reducing or stopping vascular flow in diseased branches.

Control.—Depending on their availability, plant cultivars that are resistant to verticillium wilt should be used.

Figure 24.—*(a) Dieback and leaf scorch in upper right crown caused byVerticillium wilt; (b) scorched leaves.*

Fusicoccum Canker, *Fusicoccum* spp.

Importance.—Cankers and dieback caused by *Fusicoccum* spp. are most severe on sites where trees are growing poorly. Small branches are most affected, although the bole can be attacked. Canker development is usually arrested on trees with vigorous growth; however, cankers may girdle small limbs resulting in dieback and wind breakage.

Identifying the Disease.—Annual cankers appear pale brown when young, but eventually turn dark brown with a distinct boundary between the living and dead tissues. Old, inactive cankers appear sunken and may be surrounded by callus. Dead bark may separate from the wood and disappear from old cankers not covered by advancing callus. Symptoms alone are sometimes insufficient to identify this disease.

Identifying the Fungus.—The fungus forms white masses of conidia within minute, asexual fruiting bodies (pycnidia) embedded in cankers of diseased branches (fig. 25). Conidia must be examined microscopically for identification.

Biology.—The biology of this disease is incompletely known. Numerous conidia, produced and exuded from pycnidia in cankers during wet periods, are spread by splashing rain and mechanical means. They germinate and produce hyphae that enter wounds on branches resulting from insects, frost, or mechanical damage. Stressed trees are more easily infected and colonized.

Control.—Cankers can be minimized through wound prevention, pruning out and removing limbs with cankers from landscape trees during winter, and establishing vigorous planting stock on good sites.

Figure 25.—*Fusicoccum canker on ash stems with pycnidia embedded in necrotic tissue.*

Nectria Canker, *Nectria galligena* Bres. in Strass.

Importance.—Perennial Nectria canker is among the most common and easily recognized diseases of ashes and other hardwood trees in the East and South. The disease is prevalent in cool, humid climates or where isolated pockets of cool air collect, especially on poorly drained soils.

Identifying the Disease.—Cankers begin as small, inconspicuous, dark depressions on young stems. The fungus penetrates the cambium and establishes a perennial infection. It repeatedly kills callus tissue that forms annually at the edge of the lesion, giving rise to a targetlike, perennial canker with concentric rings of dead callus (fig. 26). Cankers seldom girdle the bole.

Identifying the Fungus.—The small (1 to 2 mm diameter), bright-red to orange perithecia form from autumn through spring, near young cankers with bark, in bark crevices, or at the margins of old cankers lacking bark. Occasionally, microscopic cream-colored sporodochia form during moist weather.

Biology.—Ascospores expelled from perithecia during rainy periods in the spring and autumn are dispersed by wind and water to wounds such as frost cracks, sunscald lesions, leaf scars, hail wounds, and senescing lower branches. The ascospores germinate to produce hyphae that infect stems and initiate canker development throughout the growing season. The fungus overwinters as mycelia in cankers and as ascospores in perithecia.

Control.—Nectria canker can cause significant damage to individual trees, but the low incidence and minimal losses attributed to this disease rarely warrant control. This disease is easily prevented by avoiding bark wounds during cool, humid conditions.

Figure 26.—*Perennial target canker caused by* Nectria galligena.

DECAYS

BUTT ROTS

Importance.—Decay of the butt log in living trees is the most serious cause of cull loss for logging because it affects the highest valued log and weakens the tree. The incidence of butt rot in green ash is less than the 40-percent average for other southern hardwoods. The extent of decay in the stem increases with wound size and age.

Identifying the Diseases.—Hollows, abnormal swellings, butt bulge, old basal wounds, or fruiting bodies indicate butt rot. Decayed wood may be soft or brittle and brown to white. The decay column may extend vertically for several meters (fig. 27). Affected trunks are weakened and subject to breakage.

Identifying the Fungi.—Numerous fungi cause butt rot in ashes. The most common are *Ganoderma lucidum* (Curtis:Fr.) P. Karst., *Laetiporus sulphureus* (Bull.:Fr.) Murrill, *Lentinus tigrinus* (Bull.:Fr.) Fr., *Phellinus igniarius* (L.:Fr.) Quél., *Pleurotus ostreatus* (Jacq.:Fr.) P. Kumm., *Postia tephroleuca* (Fr.:Fr.) Jülich, *Rigidoporus lineatus* (Pers.) Ryvarden, and *R. ulmarius* (Sowerby:Fr.) Imazeki in Ito. Fruiting bodies form less frequently on ashes in the South than in northern regions, usually requiring isolation from the wood for identification.

Biology.—Exposed wounds are sites of entry of decay fungi. Spores from fruiting bodies are wind disseminated to wounds where they germinate, producing hyphae that penetrate the tree. The rate of decay varies with the fungus, wound size, host vigor, and environmental conditions.

Control.—Wound prevention is essential because most infections occur through injuries including mechanical wounds, fire scars, and frost cracks extending into the wood. Trees should be harvested before pathological rotation age to minimize degrade. Severely decayed trees should be cut and removed.

Figure 27.—*Butt rot of mature ash arising from wounds in the lower bole.*

Varnish Fungus Rot, *Ganoderma lucidum* (Curtis:Fr.) P. Karst. [Syn. *Polyporus lucidus* (Curtis:Fr.) Fr.]

Importance.—This pathogen causes a serious rot of the lower bole and roots of green and white ashes throughout North America. *Ganoderma lucidum* can kill even the largest trees.

Identifying the Disease.—Trees affected by varnish fungus rot exhibit yellowing, wilting, or undersized leaves and dead branches. Affected wood of the lower bole becomes soft, spongy, and light colored in advanced stages of decay, increasing susceptibility to windthrow.

Identifying the Fungus.—The fungus produces annual, reddish-brown basidiocarps, singly or in clusters and with or without stalks, often near the bases of trees (fig. 28). The upper surface has a smooth, lacquered appearance and a distinct, lighter margin that turns darker with age. The undersides of basidiocarps have a white, porous surface when fresh. However, basidiocarps do not necessarily indicate extensive decay or imminent death.

Biology.—Brown spores released from basidiocarps are dispersed throughout the summer during humid periods. Wounds on root flares and the lower bole are primary infection courts. Spores germinate and produce mycelia that attack the sapwood of all major roots and the butt section of the bole. Tree vigor may decline as decay of the sapwood advances. Rates of decay appear to be determined by tree vigor, which is often influenced by environmental stresses.

Control.—In urban settings, phenoxy-type herbicides applied in lawn fertilizers can sometimes predispose trees to varnish fungus rot. Cultural practices to reduce drought, water stress, and wounding are recommended.

Figure 28.—*Basidiocarps of* Ganoderma lucidum *developing on trunk and roots of ash with varnish rot.*

Sulfur Fungus Rot, *Laetiporus sulphureus* (Bull.:Fr.) Murrill [Syn. *Polyporus sulphureus* (Bull.:Fr.) Fr.]

Importance. – The sulfur fungus causes one of the most important rot diseases of ashes and many other hardwoods in the Eastern and Southern United States.

Identifying the Disease. – A reddish-brown, cubical rot of the heartwood may develop in the roots, butt, or upper stem of the tree (fig. 29a). The outward growth of the fungus from decaying heartwood may kill zones of vascular cambium and sapwood to form elongated cankers appearing as depressions in the bark.

Identifying the Fungus. – The fungus annually produces bright-yellow to orange, shelflike basidiocarps, 20 to 60 cm wide, during the summer and autumn on living trees in advanced stages of decay (fig. 29b). These fruiting bodies often develop in overlapping clusters from stem cankers and persist throughout the winter in the South. Their presence usually indicates extensive decay of the heartwood.

Biology. – Fruiting bodies release spores during wet, winter months in the South. Basidiospores germinate and produce mycelia that infect trees through dead branch stubs and wounds of trunks or occasionally through roots. The white to pale-yellow mycelium develops an extensive rot column for many years before fruiting bodies are produced.

Control. – Bark wounds in forest stands should be avoided, and protuberant dead branch stubs should be removed from high-valued trees in urban areas to accelerate formation of callus over branch stub wounds.

Figure 29. – *(a) Brown cubical rot of heartwood and sapwood in the upper trunk caused by the sulfur fungus; (b) basidiocarp of* Laetiporus sulphureus *on upper trunk of green ash.*

Perenniporia Stem Rot, *Perenniporia fraxinophila* (Peck) Ryvarden [Syn. *Fomes fraxinophilus* (Peck) Sacc.]

Importance.—Perenniporia stem rot causes a white, mottled heartrot of all major species of ashes from Tennessee westward to Arizona and northward into Canada. It is a major contributor to the decay of green ash stems in the shelterbelts of the Great Plains.

Identifying the Disease.—Heartwood decayed by this fungus is straw yellow to yellowish white, soft, and crumbly (fig. 30a). Trees in advanced stages of decay are susceptible to breakage and windthrow, especially in the shelterbelts of the Great Plains.

Identifying the Fungus.—Perennial, bracket-shaped basidiocarps usually form on the bole and major branches near branch stubs (fig. 30b). Basidiocarps are initially dirty white on the upper surface, but darken and become cracked with age. The lower surface is white and porous. They may grow to over 25 cm in diameter.

Biology.—Basidiospores released from basidocarps during wet periods germinate to produce hyphae that infect trees mainly through branch stubs and grow down the branch trace to the heartwood to initiate decay. Fruiting bodies may develop and accumulate on the bole for many years as the decay column expands. The incidence of basidiocarps on ashes is often directly proportional to trunk diameter.

Control.—Infection can be reduced by preventing wounds and trimming branch stubs to allow callus to cover the wounds, particularly in older, less vigorous landscape trees. Precautions should be taken to protect healthy crop trees during thinning and harvesting operations in forest stands.

Figure 30.—*(a) Heartwood decay caused by* Perenniporia fraxinophila; *(b) perennial conk under branch stub on living green ash.*

Importance. – Top rots result from invasion of limbs by many of the same fungi that cause butt rots. The incidence of top rot is typically lower than that of butt rot. Top rot often follows limb damage by ice or snow. Decaying limbs and tops may break, creating a hazard to people and property in urban areas. Losses of wood volume are usually insignificant.

Identifying the Disease. – Broken or decayed limbs and branch scars often indicate top rot. The vertical extent of decay behind young or small branch scars is typically insignificant, but may extend into the bole and exceed 1 m behind old, larger branch scars.

Identifying the Fungi. – Fruiting bodies can be used to identify these fungi, but they may not always be present. Identification by cultural characteristics instead of from fruiting bodies has been used with limited success because of the difficulty in isolating these fungi from the wood.

Biology. – The life cycles of decay fungi causing top rots are similar to those of fungi causing butt rots. However, different pioneer micro-organisms are usually associated with the decay process in limbs than in trunks. Basidiospores are often disseminated from conks on hardwood species other than ashes. The spores produce hyphae that infect branch stubs, wounds, and scars, initiating decay.

Control. – Recognizing top decay and early harvesting of infected trees are useful means of reducing losses. Minimizing logging injuries can help reduce top rot in growing stock. Management alternatives should favor good growth to reduce the prospect of infection. Forest stands should be managed with proper stocking to reduce storm damage.

Corticium Root Rot, *Scytinostroma galactinum* (Fr.) Donk [Syn. *Corticium galactinum* (Fr.) Burt]

Importance.—This soil-borne pathogen has a wide range of hosts and causes a white root rot of ashes and many other hardwoods and conifers. It has the potential to cause extensive damage to trees growing on poor sites, but green ash is generally less susceptible to this disease than many other species.

Identifying the Disease.—The first symptoms usually include loss of vigor and thinning of crowns. Adventitious sprouts from roots or stems and small leaves may appear before the tree dies. Trees that die typically retain dead leaves until the next year. Trees with extensive white root rot are susceptible to windthrow (fig. 31a).

Identifying the Fungus.—The fungus produces very small, inconspicuous fruiting bodies on affected roots and the root collar. Fruiting bodies can be observed only with magnification. However, a white, mycelial mat, which covers the root collar and roots below the soil line, can easily be detected by removing soil from the base of the tree (fig. 31b).

Biology.—The fungus can survive on dead roots and stumps and spread to living roots. Insects may also disseminate the fungus to healthy trees. Spores released from fruiting bodies may germinate to produce hyphae that invade dead, woody tissue. The disease gradually kills roots, resulting in decline and sometimes death of infected trees.

Control.—Control measures are not economically feasible in natural stands. In plantations or urban settings, diseased trees and affected roots should be removed to reduce the spread of the disease to adjacent trees. The triazole systemic fungicides show promise for reducing spread in high-valued trees.

Figure 31.—*(a) Corticium root rot of small green ash tree; (b) white mycelial mat on roots.*

Texas Root Rot, *Phymatotrichopsis omnivora* (Duggar) Hennebert [Syn. *Phymatotrichum omnivorum* (Shear) Duggar]

Importance. – The Texas root rot pathogen has a wide range of broad-leaved hosts throughout certain areas of the Southwestern United States. Ashes planted in old fields or residential areas may be affected by this disease.

Identifying the Disease. – The disease is characterized by sudden wilting and death of infected seedlings (fig. 32). Older trees may exhibit reduced growth and vigor. Coalescing, necrotic lesions on roots may appear down to a soil depth of 30 cm. The inner bark and cambium turn brown or black and mushy, and the root collar may be girdled. As the roots die, leaves of affected trees turn yellow or bronze before they wilt. Dieback and thin crowns are common.

Identifying the Fungus. – Spore mats develop on the soil surface during warm, wet periods. Infected roots are covered by yellowish, fluffy mycelia that penetrate the bark. Mycelial strands, with distinct, cross-shaped hyphae, are the best diagnostic microscopic feature. Black sclerotia formed from compact hyphae on dying roots may be found in the soil.

Biology. – The fungus persists in the soil for many years as sclerotia, which germinate to produce infectious hyphae that enter roots through natural openings and wounds. The hyphae colonize the root and grow up to 9 cm per year along infected roots and in the soil. The fungus is favored by warm, calcareous soils with high clay content and a pH of 7.2 to 8.5.

Control. – Soil amendments to increase soil acidity in alkaline soils inhibit growth of the fungus. Ammonium sulfate or ammonium phosphate fertilizer should be applied at 4.5 kg per 9.3 m^2. The soil should then be soaked to 30 to 60 cm. Planting trees in infected areas or on land previously planted in cotton should be avoided.

Figure 32. – *Texas root rot of ash seedlings in a commercial nursery.*

Mushroom Root Rot, *Armillaria tabescens* (Scop.) Dennis, Orton & Hora [Syn. *Clitocybe tabescens* (Scop.) Bres.]

Importance.—Mushroom root rot causes losses in more than 200 plant species in the Southern United States from Oklahoma eastward. Ash trees are more commonly attacked when growing slowly and already weakened by wounding or defoliation.

Identifying the Disease.—Leaves turn yellow, become sparse or are undersized, and drop prematurely. Roots may be partially decayed or completely girdled at the root collar. Basal lesions may extend up to 30 cm or more above the soil line. Affected trees show general loss of vigor and dieback and have increased susceptibility to windthrow.

Identifying the Fungus.—Clusters of yellow mushrooms develop at the base of infected trees from June through October, usually associated with summer rain and moist soil (fig. 33a, b). Mushrooms produce white basidiospores. The root collar must be excavated for diagnosis if mushrooms are not present. White to tan mycelial mats form under the bark (fig. 33c). Narrow, black mycelial strands (rhizomorphs) occasionally develop in bark fissures or under dead bark above mycelial mats on the root surface.

Biology.—The fungus can persist in dead or dying root tissues for many years. The rhizomorphs spread through the soil, attach to roots, and produce hyphae that penetrate healthy tree roots. Infected roots gradually die, resulting in decline and mortality of the tree. Mushrooms may be produced when large roots or the stem dies.

Control.—Cultural practices that reduce tree stress should be used. Mortality can be minimized by regular fertilization and irrigation. Infected trees and roots should be removed from the soil before replanting.

Figure 33.—*(a) Mushroom root rot in the lower trunk of mature green ash; (b) closeup of basidiocarps arising from roots in the soil; (c) root and bole rot showing white mycelium under the bark of decayed wood.*

Mistletoe, *Phoradendron* spp.

Importance.—Extensive infections and mortality are uncommon in ashes. However, infections occur typically in open-grown trees. This true mistletoe is used as greenery in Christmas decorations.

Identifying the Injury.—Affected branches may be galled or swollen at the site of infection, and multiple infections may result in loss of growth. Branches beyond the mistletoe may be stunted or die back.

Identifying the Parasite (fig. 34a, b).—The mistletoe plant has stout, green stems and dark-green, leathery leaves. It is seen best in winter growing on major and minor branches and twigs of the host. The plant has opposite branching and inconspicuous flowers and produces white berries in the fall.

Biology.—This perennial, evergreen plant grows as a parasite on tree branches. The seeds are covered with a sticky, gelatinous coating and are spread by birds and small mammals. The seeds lodge on young branches and germinate. A rootlike, penetrating structure grows into the young branch and produces a mistletoe plant. One species, *Phoradendron serotinum,* affects many other broad-leaved trees in the South and East, but is limited by temperature in its northern range (Kansas to New Jersey). Several other species of *Phoradendron* occur in the West.

Control.—Control normally is not needed in ashes, but pruning affected branches at least 30 cm below the point of infection may provide some control.

Figure 34.—*(a) Multiple infections by mistletoe in mature crowns; (b) mistletoe on main stem.*

Air Pollution Injury (fig. 35a)

Ashes vary in sensitivity to air pollutants, but in general, are intermediate in sensitivity to sulfur dioxide and hydrogen fluoride emitted during various types of manufacturing processes. Sulfur dioxide kills the leaf tissue between veins, whereas hydrogen fluoride kills the leaf margins. White ash is sensitive to ozone, which causes purple stippling on upper surfaces of older foliage. Extremely sensitive cultivars may experience growth loss. The main precursors of ozone originate from automobile exhaust.

Chemical Injury (fig. 35b, c)

Ash trees are sensitive to many chemicals, but the most frequent damage is caused by herbicides. Symptoms are highly variable and include leaf curl, chlorosis, partial leaf necrosis, and premature leaf fall. Affected branches or the entire crown may drop its leaves and refoliate repeatedly during a single growing season. Young trees may be killed by acute exposures. Symptoms of air pollution or chemical injury may be difficult to distinguish from symptoms induced by other abiotic agents or infections caused by biotic agents.

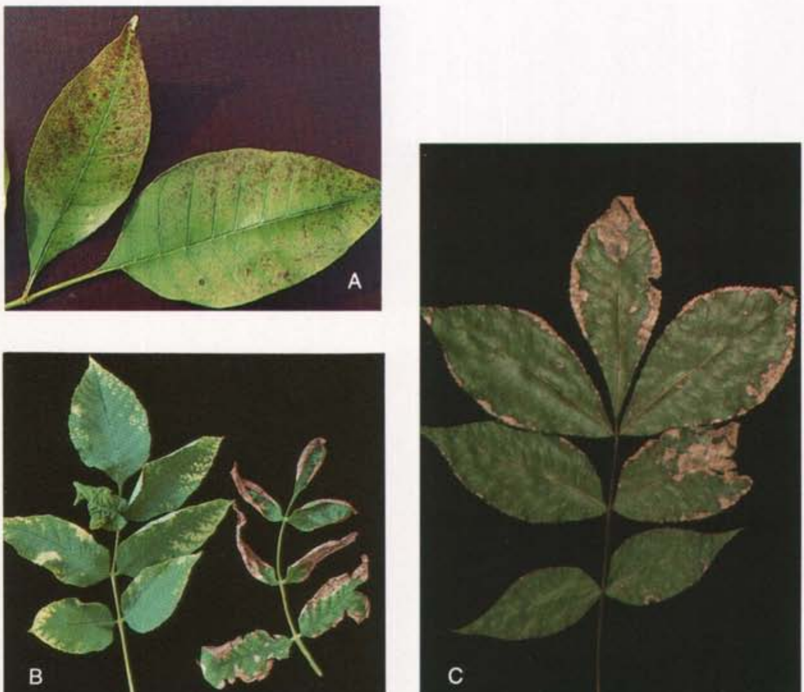

Figure 35.—*(a) Purple stippling caused by ozone; (b) leaflet curling and scorching caused by an herbicide; (c) marginal necrosis caused by ammonia.*

PESTICIDES

Registered chemicals for control of insects that attack ashes. (See labels for dosages, application methods, and restrictions.)

Insect	Insecticide
Ash sawflies	Acephate Carbaryl Chlorpyrifos Diazinon Malathion
Sphinxes	Acephate Carbaryl Chlorpyrifos Diazinon
Ash plant bugs	Acephate Chlorpyrifos Diazinon
Woolly ash aphid	Acephate Carbaryl Chlorpyrifos Diazinon Malathion
Borers	Chlorpyrifos Lindane
Scale insects	Carbaryl Chlorpyrifos Diazinon Methoxychlor
Planthoppers	Carbaryl Diazinon
Ash bark beetles	Chlorpyrifos Lindane
Mites	Acephate Carbaryl Diazinon Dicofol
Seed weevils	Acephate Carbaryl Diazinon
Leafroll midges	Carbaryl Diazinon
Spring cankerworm Fall webworm Forest tent caterpillar	*Bacillus thuringiensis* Chlorpyrifos Diazinon

Registered chemicals for control of diseases that attack ashes. (See labels for dosages, application methods, and restrictions.)

Disease	Fungicide	Disease	Fungicide
Damping-off	Captan (seed treatment) Chloroneb Dazomet Etridiazol	Leaf spots	Benomyl Captan Dodine Ferbam
	Methyl bromide + chloropicrin (Preplanting soil fumigation)	Powdery mildews	Benomyl Chlorothalonil Lime sulfur
		Ash dieback	Treat for causal agent
Anthracnose	Benomyl Metallic copper Zineb	Root rots	Captan Etridiazol
Ash rust	Captan Ferbam		

MAINTAINING TREE HEALTH

Trees should be managed to optimize vigor because healthy trees are less susceptible to attack and injury by insects and diseases. The following cultural practices, singly or in combination, can be used to promote and maintain good tree health in forest stands, plantations, nurseries, shelterbelts, and ornamental plantings:

1. Match ash species and seed source with their adapted sites.
2. Use vigorous planting stock, and select pest-resistant cultivars when available.
3. Ensure that trees receive sufficient water, nutrients, and sunlight through irrigation, fertilization, and proper spacing.
4. Maintain proper stocking in forest stands.
5. Use sanitation practices such as pruning out and removing dead and symptomatic limbs and branches, and raking and removing insect-infested and diseased leaves; this reduces levels of hibernating insects and overwintering inoculum reservoirs that initiate new infections the following year.
6. Prevent or minimize injuries and wounding from harvesting, fire, or other sources that can create easy entry points for ash pests.
7. Utilize cultural practices that favor natural controls such as birds and other predators, parasites, and insect pathogens.
8. Exercise caution in the use of broadleaf herbicides on lawns around ornamentals and shade trees because these herbicides have the potential to damage ash trees.
9. Be aware of early insect feeding or disease symptoms; this will allow for the greatest number of options in managing a pest problem.
10. Use pesticides only when and where they are absolutely needed and avoid using more than the recommended rates to prevent development of pest resistance.

GLOSSARY

Acervulus(-i) – a saucer-shaped, fungal structure embedded in host tissue in which conidia form.

Aeciospore – a type of spore formed in an aecium of a rust fungus.

Aecium(-ia) – a cuplike, fruiting body produced by rust fungi.

Ascocarp – the sexual, fruiting body of Ascomycetes.

Ascospore – the sexual spore of Ascomycetes.

Basidiocarp – the sexual, fruiting body of Basidiomycetes.

Basidiospore – the sexual spore of Basidiomycetes.

Bole – the main stem or trunk of a tree.

Butt – the lower bole of the main stem.

Callus – a protective tissue that forms to cover wounds on stems and branches.

Cambium – a thin layer of cells between the phloem and xylem.

Canker – a definite, localized, necrotic lesion of the bark and cambium.

Conidium(-ia) – an asexual, fungal spore.

Conidiophore – a fungal structure bearing asexual spores.

Conk – a basidiocarp of wood decay fungi.

Crochet – a tiny hook on the prolegs of caterpillars.

Damping-off – a necrotic disease of seedlings that causes rotting of the hypocotyl and prevents emergence of the new shoot or causes the new shoot to fall over.

Dieback – the gradual dying of a tree crown usually from the top down and from the outside in.

Elytra – the hard forewings (wing covers) of beetles.

Frass – wood fragments mixed with borer excrement.

Gallery – a long passage chewed in the bark, cambium, or wood.

Hypha(-e) – a single filament of a fungus mycelium.

Infection court – the point where a pathogen enters its host.

Inoculum(-a) – the spore, mycelium, or other propagule of a pathogen that initially infects a host.

Maggot – a legless larva of various flies.

Mycelium(-ia) – a collection of hyphae that make up a fungus body.

Necrotic – composed of dead cells.

Pathological rotation – the harvesting of trees before the age at which the rate of wood volume loss due to decay fungi exceeds the annual production of new wood.

Perennial canker – a canker that expands indefinitely.

Perithecium(-ia) – a flask-shaped ascocarp in which ascospores are formed.

Phloem – the food-conducting vascular tissue under the bark of trees.

Pronotum – the upper surface of the prothorax.

Pseudothecium(-ia) – the flask-shaped ascocarp similar to a perithecium but without a definite fungal wall.

Rhizomorph – a compact mass of vegetative hyphae that have fused together to form a thick, usually dark, rootlike strand.

Sapwood – the outer, water-conducting wood (xylem) of the tree stem.

Sclerotium(-ia)—a firm, often rounded, compact mass of fungal hyphae that form a resistant survival structure.

Spermatium(-ia)—a nonmotile, uninucleate spore (gamete) required for sexual reproduction in some fungi.

Spermogonium(-ia)—a fungal structure in which spermatia are produced.

Sporodochium(-ia)—a cushion-shaped stroma covered with conidiophores.

Stroma(-mata)—a mass or mat of hyphae in or on which fruiting bodies form.

Teliospore—the spore of a rust fungus from which basidia and basidiospores form.

Telium(-ia)—a fruiting structure producing teliospores of rust fungi.

Urediniospore—the spore of a rust fungus, formed in a uredinium, that can repeatedly infect its host.

Uredinium(-ia)—a fruiting structure of a rust fungus that gives rise to urediniospores.

Witches' broom—an abnormal growth of branches forming a broomlike cluster.

Solomon, J.D.; Leininger, T.D.; Wilson, A.D.; Anderson, R.L.; Thompson, L.C.; McCracken, F.I. 1993. Ash pests: A guide to major insects, diseases, air pollution injury and chemical injury. Gen. Tech. Rep. SO-96. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 45 p.

This booklet will help nurserymen, resource managers, pest control personnel, and homeowners to prevent, identify, and control ash pests.

Keywords: Biology, borers, control, defoliators, *Fraxinus,* fungi, identification.

CAUTION

Pesticides used improperly can be injurious to humans, animals, and plants. Follow the directions and heed all precautions on the labels.

Store pesticides in original containers under lock and key—out of the reach of children and animals—and away from food and feed.

Apply pesticides so that they do not endanger humans, livestock, crops, beneficial insects, fish, and wildlife. Do not apply pesticides when there is danger of drift, when honey bees or other pollinating insects are visiting plants, or in ways that may contaminate water or leave illegal residues.

Avoid prolonged inhalation of pesticide sprays or dusts; wear protective clothing and equipment if specified on the container.

If your hands become contaminated with a pesticide, do not eat or drink until you have washed. In case a pesticide is swallowed or gets in the eyes, follow the first-aid treatment given on the label, and get prompt medical attention. If a pesticide is spilled on your skin or clothing, remove clothing immediately and wash skin thoroughly.

Do not clean spray equipment or dump excess spray materials near ponds, streams, or wells. Because it is difficult to remove all traces of herbicides from equipment, do not use the same equipment for insecticides or fungicides that you use for herbicides.

Dispose of empty pesticide containers promptly. Have them buried in an approved sanitary land-fill dump.

NOTE: Some States have restrictions on the use of certain pesticides. Check your State and local regulations. Also, because registrations of pesticides are under constant review by the Federal Environmental Protection Agency, consult your county agricultural agent or State extension specialist to be sure the intended use is still registered.

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