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WAYNE COUNTY MASTER GARDENER PLANT CLINIC

Identifying Tree Diseases

Manual Contents: Each disease profile is organized by type and includes the following important information: Hosts, Symptoms and Signs, Life -cycle, Management, and Diagnostic photographs.

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Brown Spot Needle Blight
(*Mycosphaerella dearnessii*)

Hosts

The most important host of this fungal disease in the South is longleaf pine (*Pinus palustris*).

Symptoms and Signs

Symptoms are most noticeable on low growing branches and small seedlings. Look for needle lesions from May through October. There are two types of lesions to look for, one starts out a straw yellow color and develops brown margins, the second type is a brown spot with a yellow band. Diseased needles often times have brown tips. Both needle spots increase in size over time, resulting in needle death. Killed needles turn reddish brown before dropping off. Longleaf pine seedlings often die while still in the grass stage after repeated defoliations.

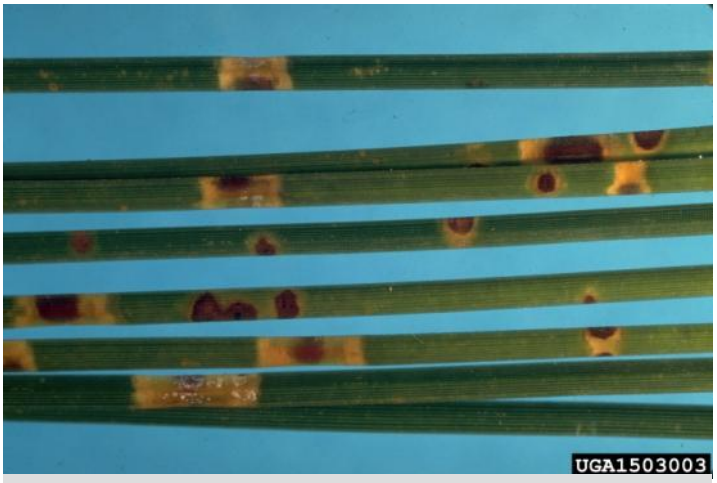
Both sexual and asexual spores, which are produced in fruiting bodies on needles throughout the year in the South, are the most common signs to look for. Boat-shaped spores can be collected from the gray to black spots on first-year needles for positive identification using a microscope.

Life-Cycle

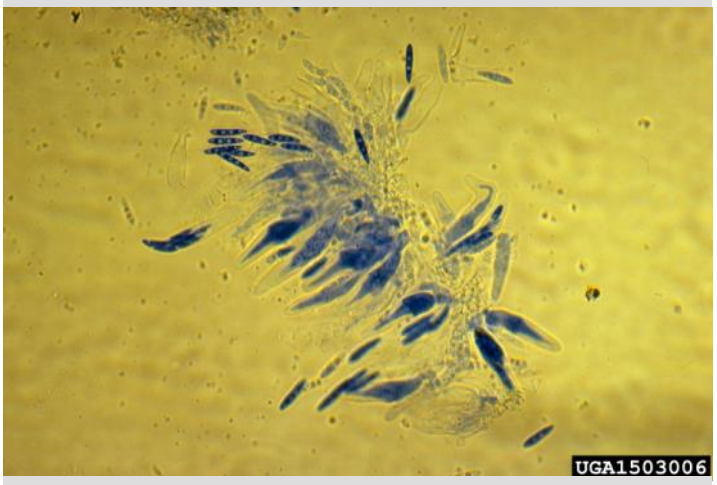
M. dearnessii survives the winter in lesions on dead needles, either still attached to the plant or in fallen needles. New infections occur from spring through summer as spores are spread from these infected needles via splashing and wind driven rain. Young succulent needles are more susceptible to infection than older needles and needles need to be wet for infection to occur. Warm, wet weather favors this disease and infection in longleaf pine is highest during wet periods when day and night temperatures are about 30°C and 21°C, respectively.

Management

Plant resistant pine species and only use healthy nursery stock.. Eliminate and destroy small infected trees. In longleaf pine plantations managed with fire, burn during the dormant season in order to eliminate infected needles that have fallen on the forest floor. Fungicide sprays can be effective in nurseries, but are not recommended for homeowners. Both chlorothalonil or Bordeaux mixture provide excellent disease control. Begin spraying in the spring when new needles are 1 to 2 inches long.



Brown spot lesions on longleaf pine needles. Spots can occur any time of year, but most often are seen from May to October.



Conidia of *Mycosphaerella dearnessii* are boat-shaped. Spores can be collected and viewed under a microscope for positive identification.

Symptoms on longleaf pine seedlings in grass stage. Year-old needles are brown, and current season needles exhibit brown tips.

Needle Casts
(*Ploioderma* spp. & *Lophodermium* spp.)

Hosts

All southern pines are susceptible with the exception of long-leaf pine (*Pinus paultris*). Needle cast fungi are often very host-specific.

Symptoms and Signs

Needle cast is a general term for a group of foliar diseases on pine which cause small spots or lesions on needles, needle browning, needle death, and premature needle drop. Most needle cast fungi infect young, newly formed needles in the late spring or early summer, however symptoms do not begin to develop until the following winter or early spring. The first symptoms of infection are small yellow spots on needles less than one year old. Yellow spots begin to turn brown and expand to form bands that surround the entire circumference of the needle. In spring, the bands may turn pale yellow or grayish-brown. Tips of the needles and tissue between multiple bands will then turn brown and die; the base of the needle will often stay green however.

Infected needles (especially needles with completely dead tips) will begin to prematurely drop in the late spring and throughout the summer. On severely diseased trees, all needles from the previous growing season may be lost, leaving only new growth. Heavily defoliated branches and shoots may not grow very much, therefore new needles produced will be very close together around the shoot tip, giving it a tufted appearance.

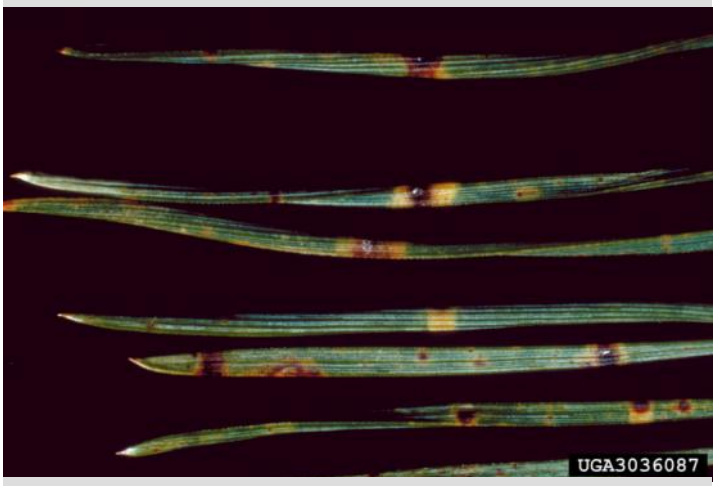
Life-Cycle

In late spring (April-May), sticky spores (sexual spores) are produced on lesions from the previous year's infections. The spores are spread by splashing rain or may be carried by strong winds for short distances. Infection can only occur during wet and preferably cool weather. The fungus grows slowly, and the first symptoms of infection will not be visible until the following spring. The fungus eventually expands to surround the entire needle, at which time small black fruiting bodies form within the lesion and produce sexual spores. There is only one disease cycle per year.

Management

Management for needle cast is usually not necessary as it causes no serious harm to the tree; however aesthetic concerns may warrant an attempt to reduce disease severity. Plant pines on a wide spacing and keep the area clear of vegetation to improve air circulation. Destruction of diseased needles that have fallen is ineffective because these needles have already released their spores before falling to the ground.

Pine needle cast symptoms on loblolly pine.



Small, yellow-brown, bar-like spots form on the previous year's needles.

Mature spore-producing fruiting bodies are football-shaped.

Passalora Needle Blight on Leyland Cypress (*Passalora sequoia*)

Hosts

Eastern red cedar (*Juniperus virginiana*), bald cypress (*Taxodium distichum*), and most commonly Leyland cypress (x *Cupressocyparis leylandii*) are all susceptible to this fungal disease.

Symptoms and Signs

Symptoms usually appear during summer months and typically the disease only affects one-year old foliage. Common symptoms include browning of needles and eventual needle drop. Passalora needle blight symptoms start on lower branches near the trunk and then spread outward toward branch tips. The loss of foliage spreads upward and outward from year to year. In severe cases, the entire tree will turn brown except for the new growth at the tips of the branches.

Brownish spores develop during late spring to summer on infected foliage.

Life-Cycle

This pathogen overwinters in diseased leaves on living plants. Spores are produced throughout the growing season, most abundantly during wet weather in late spring and summer. Spores are dispersed primarily by rain, overhead irrigation, and wind. Once a spore lands on wet foliage it will germinate and enter the leaves through the stomata. Infections occur throughout summer and symptoms appear 2-3 weeks after infection from mid-summer to late fall.

Management

Plant trees at their proper spacing in order to allow adequate air flow between foliage, to reduce prolonged periods of leaf wetness, which is prone to infection. To reduce the spread of spores, avoid overhead irrigation or restrict it to early morning hours. Since spores can be spread via pruning tools, it is important to sterilize tools with a 10% bleach solution following the pruning of diseased limbs. Fungicides are available, however they are usually not practical for homeowners and are therefore not recommended. Encourage homeowners with diseased Leyland cypress hedge rows to consider replanting with a diversity of plants. Evergreen plants to consider interplanting Leyland cypress with include hollies (*Ilex* spp.), wax-myrtle (*Myrica cerifera*), Eastern red cedar, and thuja `Green Giant' (*Thuja* (*standishii* x *plicata*) 'Green Giant').

Passalora needle blight symptoms start on lower branches near the trunk and then spread outward toward branch tips.

Symptoms, such as browning needles, usually appear during summer months.

Spore forming structures are visible on infected needles.

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Anthracnose
(*Caused by Several Fungi*)

Hosts

Anthracnose is a general term for a group of diseases on hardwoods that cause lesions on leaves, twigs, and fruits. The fungi responsible for anthracnose are *Gloeosporium* spp., *Gnomonia* spp., and *Apiognomonia* spp. Hosts include a wide variety of hardwoods. Common hosts include oak, maple, sycamore, ash, walnut, and dogwood.

Symptoms and Signs

Symptoms vary with species, but in general the most obvious symptoms are the leaf lesions produced in the spring and expanding throughout the summer. Lesions often begin as pale green or greenish-grey blotches, but then turn yellow, tan, reddish-brown, or brown.

Lesions tend to begin along leaf veins (because the depressions along veins hold water for a longer period of time and spores tend to collect there), but often rapidly expand. Severely infected leaves may have a scorched appearance, becoming almost completely brown, wilted, or cupped. (*Note: drought symptoms and/or leaf scorch differ because the browning and wilting of leaf tissue begins at the leaf tips and leaf margins and progresses inward*).

Some trees respond to infection by prematurely shedding leaves (e.g. sycamore and ash), but others retain their leaves until normal leaf drop in the fall (e.g. oak). In sycamore, the fungus is able to grow out of leaves into adjacent twigs where it causes small cankers, shoot dieback, and witches brooms or deformed twigs.

Life-Cycle

Most anthracnose fungi infect their hosts during the spring, just as the first new leaves begin to expand, and continue through the summer while environmental conditions are suitable. Spores are released from last year's diseased tissue (most commonly from fallen leaves). Spores can be spread by wind or rain-splash, and can only infect soft, succulent tissues such as new shoots, flowers, and fruits, but leaves are the most severely infected. The fungus obtains nutrients from plant cells, and in turn the cells are killed creating the leaf lesion. The lesion expands as the fungus spreads. During periods of sustained wetness and cool temperatures, spores are produced from leaf lesions which can re-infect the same leaf or neighboring leaves. New infections usually do not occur after mid-summer because conditions are too warm and dry. Most anthracnose fungi over-winter on the ground in fallen leaves, but some (e.g. sycamore anthracnose) can also spread from the leaves into adjacent shoots and over-winter in the twigs where they directly infect new leaves in the spring.

Management

Management for anthracnose is usually not necessary as it causes no serious harm to the tree; however aesthetic concerns may warrant an attempt to reduce disease severity. Plant trees on a wide spacing, keep the surrounding area clear of vegetation, and prune properly to improve air circulation within the crown.

Spot anthracnose on flowering dogwood (*Cornus florida*).

Spot anthracnose on dogwood leaf.

Sycamore anthracnose. Lesions tend to run along leaf veins.

Powdery Mildew
(Caused by Several Fungi)

Hosts

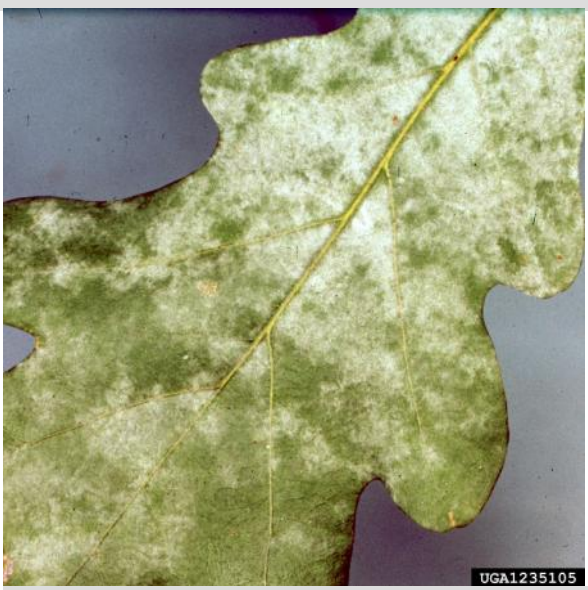
Powdery mildew is caused by numerous fungi (*Erysiphe* spp. *Phyllactinia* spp., and others). Powdery mildew has an extremely wide host range; trees most commonly affected include crapemyrtle (*Lagerstroemia indica*) and flowering dogwood (*Cornus florida*).

Powdery mildew on common lilac (*Syringa vulgaris*)

Symptoms and Signs

Symptoms usually appear late in the growing season during periods of high relative humidity. Injury commonly seen on infected plants includes stunting and distortion of leaves, buds, growing tips, and fruit.

The presence of white to gray fungal growth over leaf surfaces is the most common sign of the disease. Powdery mildew begins as circular, powdery white spots and expands to coat the entire leaf surface. In most cases this fungal growth can be removed by rubbing the leaves.



Diagnostic white fungal growth on infected oak.

Life-Cycle

The fungi that cause powdery mildew are spread by wind blown spores that blow from infected leaves to new hosts throughout the entire growing season. Powdery mildew fungi are generally host specific, for example the fungus species infecting lilacs will not cause powdery mildew on oak. During the winter the fungus survives on infected plant parts and in fallen leaf debris. During this time it may produce resting structures known as cleistothecia, which appear as tiny black `pepper-like' spheres on the underside of leaves that can survive harsh environments. In spring, spores are released from the cleistothecia and carried by wind to susceptible leaves. Once a spore finds a suitable host it reproduces asexually, leading to an increase in the spread and infection of the disease throughout the growing season.

Management

Plant resistant cultivars. *Lagerstroemia indica x fauriei* hybrids are resistant to powdery mildew. These include, but are not limited to, `Apalachee' and `Fantasy'. Flowering dogwood cultivars `Appalachian Joy' and `Appalachian Blush' are very resistant to powdery mildew.

The fungi that cause powdery mildew can overwinter on dead leaves so it important to keep the surrounding area clear of diseased vegetation. Plant trees on a wide spacing and prune properly to improve air circulation within the crown. The use of fungicides is rarely warranted in a landscape situation.

Pecan (*Carya illinoinensis*) fruit infected with powdery mildew.

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Fusiform Rust
(*Cronartium quercuum* f. sp. *fusiforme*)

Hosts

This fungal disease attacks several southern pine species, but is most damaging on slash pine (*Pinus elliottii*) and loblolly pine (*Pinus taeda*). Oaks, such as water oak (*Quercus nigra*), willow oak (*Q. phellos*), and southern red oak (*Q. falcata*), serve as important alternate hosts for this disease, but do not sustain any damage.

Symptoms and Signs

On pine, the most obvious symptom of infection is the formation of a spindle-shaped gall on a branch or main stem. The gall may be pitch soaked and occasionally exude sap. During cool spring months, bright orange spores are often produced on the gall surface. These aeciospores are blown off by the wind and serve to infect oak leaves.

On oak, symptoms are limited to small leaf spots that may be chlorotic or necrotic. A key diagnostic characteristic on oaks are the bright orange spores (urediospores) produced on the underside of the leaf.

Life-Cycle

Cronartium quercuum f. sp. *fusiforme* has five spore stages and takes two years or longer to complete its life-cycle. Starting in the spring (February-April), orange aeciospores are produced on gall surfaces. These aeciospores are dispersed by wind and infect the leaves of susceptible oaks, where they cause leaf spots. After one week, bright orange urediospores are produced on the underside of the leaf, which serve to re-infect the same leaf or nearby oak leaves in order to build up the pathogen population. A week following, urediospore production, small brown teliospores are also produced on the underside of the leaf. These spores can survive for several months, until conditions are just right (60-80F, 95-100% RH), at which time they germinate and produce basidiospores. The basidiospores are also blown by the wind, back to nearby pines where they can infect needles. The fungus grows into the branch or stem, forming a gall. Aeciospores are produced on the gall during the next spring, thus completing the life cycle.

Management

Plant resistant pine species. Shortleaf pine (*P. echinata*) is highly resistant and longleaf pine (*P. palustris*) is relatively resistant. Avoid planting susceptible species in areas with historically high incidence of fusiform rust. Prune out galls within 8 inches of the main stem. Avoid practices that over-stimulate growth such as fertilization, as this has been shown to increase the incidence of rust.

A fusiform rust canker on loblolly pine. The pathogen overwinters in pine cankers.

Fusiform rust gall on pine. Orange spores are produced on the surface of pine galls in spring.

Urediospores are found on the underside of oak leaves in late spring.

Cedar-Apple Rust
(*Gymnosporangium juniperi-virginianae*)

Hosts

Cedar-apple rust is caused by the fungus *Gymnosporangium juniperi-virginianae*.The primary host is apple (*Malus domestica*) and the alternate host is eastern redcedar (*Juniperus virginiana*).

Symptoms and Signs

The fungus forms galls on the branches of eastern redcedar. Branches with galls experience some dieback, but otherwise cause little harm to the tree. Once galls are mature, bright orange, gelatinous, spore-producing telial horns emerge from the gall. Telial horns are most commonly seen following a warm, spring rain. Telia gelatinize and dry several times in response to intermittent rains. The galls eventually dry and die, but remain attached to twigs for a year or more.

Yellow or orange leaf spots form on the apple host in the spring. Powdery, yellow-orange spores are produced on the undersides of the apple leaves. The leaf spots turn necrotic as the disease progresses, causing premature defoliation and crop reduction in apple.

Life-Cycle

Rusts spend the winter on redcedar as stem galls. In the spring, bright orange telial horns emerge from the galls in response to warm, wet weather. Basidiospores, are released in the spring from these gelatinous galls, to infect the young leaves and fruit of apple trees. Spores called aeciospores are produced on the underside of apple leaves that infect redcedar from midsummer to early autumn. Galls form on redcedar the next year, and telia are produced on galls 21-22 months after infection. The cedar-apple rust life-cycle takes two years to complete.

Management

Galls can be picked and destroyed from redcedar. Use resistant apple and *Juniperus* cultivars. Apple cultivars that normally show good to excellent resistance to cedar-apple rust include `Red Delicious', `McIntosh', `Arkansas Black', and `Winesap', just to name a few. Removing redcedar trees growing near apple orchards may reduce the occurrence of the disease on apple, however spores can travel several miles. In apple orchards, fungicides can be used to prevent spring basidiospore infections. Refer to the publication FDIN002 (Disease and Insect Management in the Home Orchard), for spray schedule information.

Inactive reddish-brown second-year galls on eastern redcedar.

Telial horns contain spores that are released in the spring to in infect apple leaves.

Cedar-apple rust symptoms on apple (*Malus domestica*).

Fire Blight
(*Erwinia amylovora*)

Hosts

Fire blight is a disease caused by the bacteria *Erwinia amylovora*. There are more than 100 species of plants known to be susceptible to fire blight; all are in the Roseaceae family. Trees susceptible include apples, hawthorns, pears, and mountain-ash. The disease can also occur (but is far less common) in the stone fruits: peach, cherry, and plum.

Symptoms and Signs

Blighting flowers is usually the first symptom to appear in spring. Flowers will darken, droop, shrivel, and turn black. The tips of infected shoots will also droop and turn black and bend over into a shepherd's crook shape. If many shoots are infected, trees will appear to be burned or scorched, hence the name "fire blight".

Cankers may form when branches and stems are infected by the bacteria. Bark on cankers may appear raised and slightly blistered, especially when cankers are actively expanding during the growing season. Cankers can eventually girdle and kill branches or the entire tree. Bacteria may be visible oozing from or near infected plant parts during warm, humid weather.

Life-Cycle

Bacteria overwinter in diseased plant parts including cankers, twigs, and buds. When warm humid weather returns, small drops of bacteria ooze from infected plant parts and can be transmitted to new growth via rain-splash, wind-driven rain, irrigation water, insects, birds, and pruning tools. There are many insects known to vector the fire blight bacteria, but the most common are pollinators such as bees and flies. Once the bacteria enters the plant through small wounds or openings populations can double once every hour and spread through plant tissue at rates of up to 10 inches a day. As bacteria spread, they release enzymes that kill and dissolve plant cells; symptoms begin to appear a few weeks after infection.

Management

Prune off infected plant tissues as soon as they are observed; be sure to prune 8 inches or more from the nearest symptomatic tissue. Prune trees regularly to increase air circulation in the crown. Make sure to sanitize pruning tools with a 10% bleach solution after use to prevent spreading the disease. Most new infections start on flowers; removal of flowers on small trees can prevent infection. Bactericides are available, but proper timing of applications is critical and is difficult to accomplish effectively. Examine trees thoroughly 1 -3 weeks after warm wet periods in the spring for symptomatic tissue and remove.

Shoot blight on crabapple tree. Infected shoot tips will turn brown or black and bend over into a shepherd's crook shape as seen here.

Dead branch symptomatic of infection with fire blight. This symptom is often referred to as a `strike'.

Erwinia amylovora oozing from an infected pear leaf.

Bacterial Leaf Scorch
(*Xylella fastidiosa*)

Hosts

Bacterial leaf scorch is caused by a bacterial infection of a tree's water conducting tissue. The pathogen is *Xylella fastidiosa*. There are hundreds of known hosts of bacterial leaf scorch. Trees include maple, buckeye, hackberry, dogwood, sweetgum, sycamore, plum, oak, and elm.

Symptoms and Signs

Infection is perennial; bacteria are able to survive from year to year in the host vascular system. Bacteria interfere with water transport in the xylem, therefore symptoms closely resemble those of drought and other vascular diseases. Leaf margins turn red or yellow; then leaves will wilt and turn brown especially during the summer months. A red or yellow band often separates brown from green tissue. Older leaves are usually scorched first, with symptoms progressing towards shoot tips. Scorched leaves are retained on the tree into the fall.

Trees may have decreased fruit production, delayed bud break, reduced growth, stunting, branch dieback, and eventually death. Leaves usually expand normally each year; then symptoms begin to appear in late spring and progress throughout the summer. Hot droughty weather makes symptoms worse. Symptoms may initially appear in isolated branches or sections of the crown, but eventually spread throughout the tree. Symptoms can fluctuate in severity from year to year.

Life-Cycle

Bacteria must be introduced into a tree's vascular system by insects in order for infection to occur. Common insect vectors include spittlebugs and sharpshooter leafhoppers; insects pick up the bacteria from infected trees and transmit it during feeding to healthy trees. Bacteria multiply rapidly in the xylem and are carried faster upward in the transpiration stream , but also spread downward. Symptoms develop within a few weeks to a year depending on tree health and species. The bacteria overwinter in roots and stems and each year they spread to new xylem vessels. The bacteria produce enzymes that dissolve cell wall components and plug the vascular system.

Management

There are currently no effective treatments for bacterial leaf scorch.

Bacterial leaf scorch symptoms. Older leaves will have a "scorched" curled appearance while younger leaves at branch tips will appear healthy.

Bacterial leaf scorch symptoms on an American sycamore (*Platanus occidentalis*) leaf.

Symptoms on turkey oak (*Quercus laevis*) leaves.

Alcoholic Slime Flux

(Caused by Bacteria)

Hosts

Slime flux is not a serious disease of trees, but is very common and often of great concern to homeowners. Found very commonly in elm (*Ulmus Americana*). Also found in maple (*Acer* spp.), oak (*Quercus* spp.), sweet-gum (*Liquidambar styracifula*), sycamore (*Platanus occidentalis*), willow (*Salix* spp.), hemlock (*Tsuga* spp.), and fir (*Abies* spp.).

Symptoms and Signs

Symptoms usually appear during the spring or summer, but can occur in the fall. Alcoholic slime flux is usually noticed when fluid pressure builds up and breaks through the outer - sapwood and bark. The fluid will have a sour smell, and leave grey, brown, or black streaks down the bark. Alcoholic slime flux will always be associated with an old crack, wound, or cavity. The flux is colorless (though may be frothy white under pressure) and has a fermented odor. It will also discolor bark. Alcoholic slime flux is highly attractive to insects such as bees, wasps, ants, butterflies, and moths. Fluid darkens when exposed to air and may be produced so excessively as to flow or pool on the ground below. Various fungi and bacteria colonize the fluids once exposed to oxygen, and therefore the ooze may become slimy and bad smelling.

Slim flux infection on American elm (*Ulmus americana*)

Life-Cycle

Alcoholic slime flux occurs when microorganisms (fungi and bacteria) invade cracks, wounds, or cavities and begin to ferment sap and dead wood. Ethanol and gases are produced during the fermentation process, which cause pressure to build. Excess pressure is relieved when liquid and gas is expelled through the surface.

Management

There are no preventative measures for slime flux. Fluids can be washed from the bark surface with a mild soap solution. Do not attempt to cut into or drain pockets of wet -wood; introduction of oxygen into these cavities will allow wood rotting fungi to invade, and severe decay can occur.

Close-up of sap weeping from infected tree. This slim is alcoholic and attracts large number of insects.

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Laurel Wilt
(*Raffaelea lauricola*)

Hosts

Discovered in 2003, laurel wilt has rapidly become a disease of serious concern in the southeast. The laurel wilt fungus (*Raffaelea lauricola*) can kill mature trees very quickly, is vectored by a small ambrosia beetle (*Xyleborus glabratus*) from Asia, and is spreading through the southeast at approximately 20 miles per year. It affects plants of the laurel family; most commonly red bay (*Persea borbonia*). Also susceptible are sassafras, avocado, swamp bay, silk bay, pondberry (endangered-U.S.), pond spice (threatened-NC), Northern spicebush, and California laurel.

Symptoms and Signs

Symptoms of the disease may be similar to drought. Leaves begin to turn olive grey, then reddish-brown, and begin to droop before wilting completely and turning brown. Leaves are retained on dead trees for a year or more. Symptoms may start in an isolated branch or in the top of the tree, but will spread throughout the entire tree rapidly. Most trees wilt and die a few weeks or months after symptoms first appear.

Dark staining in the outer sapwood is clearly visible in dead or dying trees. Staining will be dark purplish or black, and be easily seen by looking at wilted branches in cross section or removing the bark to expose the xylem. Staining in dead trees extends through the roots to all branches and twigs.

Life-Cycle

The red bay ambrosia beetle is a "fungus farmer". It creates galleries in dead or dying trees to grow the fungus on which it feeds. The beetle carries the fungus with it from tree to tree, and coincidentally, the fungus that the red bay beetle farms is highly pathogenic on the beetle's preferred host tree. This creates a symbiotic relationship in which the fungus kills trees for the beetles to invade, and the beetles farm and carry the fungus to new trees. It may only take one or a couple of beetles to infect a tree. Beetles cannot attack healthy trees, so it is likely that the fungus is introduced to the tree during failed attempts by beetles to enter. Only after the tree is dead or dying can beetles return to infest the tree and farm the fungus.

Once introduced into the tree's vascular system, the fungus rapidly spreads in the sapwood throughout the entire tree. The tree responds by plugging its vascular system to prevent spread of the fungus, but this also cuts off the tree's supply of water. Therefore, trees wilt and die rapidly after infection.

Management

There are currently no effective control options. Research is being conducted on systemic insecticides and fungicides. Human movement of infested wood is responsible for the diseases rapid spread through the southeast; without human assistance the disease can only spread approximately 20 miles per year. Although laurel wilt has not been reported in NC yet, any suspected incidence of laurel wilt should be reported to NCDFR Pest Control staff immediately (919-731-7988).

Partial canopy wilt due to laurel wilt infection.

Vascular staining caused by *Raffaelea lauricola*.

Cross section of vascular staining.

1000 Cankers Disease
(*Geosmithia morbida (proposed)*)

Hosts

Thousand cankers disease is caused by a pathogen vectored by the walnut twig beetle (*Pityophthorus juglandis*) and is caused by the fungus *Geosmithia morbida* (proposed). The walnut twig beetle can feed on multiple walnut species, but black walnut (*Juglans nigra*) is the beetle's preferred host.

Symptoms and Signs

The most obvious symptoms are dieback and mortality. Black walnut trees in the final stage of thousand cankers disease will often times have large areas of foliage that rapidly wilt. Small, round entry/exit holes may be present along infested branches or stems and adult walnut twig beetles may be present at certain times of the year. Some resin weeping may also be seen around beetle entry holes. Infected trees will have walnut twig beetle galleries and associated cankers can be found under the bark.

Life-Cycle (Western US)

Thousand cankers is an insect-disease complex. This disease was first confirmed east of the Mississippi River in Knoxville, TN in July 2010, so little is known about the life-cycle in this area. In the west, adult walnut twig beetles spend the winter within insect cavities in the bark of the host trunk.. Adults become active again in April, at which time they fly to new hosts, mate, and create new egg galleries. During the construction of egg galleries, the fungus *Geosmithia* is introduced, where it begins to grow around the tunnels. The *Geosmithia* fungus causes a small brownish-black canker under the bark and around the beetle's entry hole. Walnut branches and stems may be attacked by many beetles, resulting in numerous small cankers which eventually overlap and girdle the tree. Trees are often killed within three years after initial symptoms are noted. The walnut twig beetle produces a second generation from mid-July through late August. In the fall, adult beetles begin hibernation until the following spring.

Management

There are no known management tactics at this time. Any walnut trees suspected of being infected with thousand cankers disease should be immediately reported to the N.C. Department of Agriculture Plant Industry Division in Raleigh (919)733-3933, or to one of the two North Carolina Forest Service Pest Control Branch offices in Goldsboro (919)731-7988 or Morganton (828)438-3793 for confirmation. Do not move wood suspected to be infected with thousand cankers disease, this includes firewood.

Die-back symptoms of thousand cankers disease of black walnut.

Branch cankers that have developed around twig beetle galleries.

Exit wounds made by adult walnut twig beetles.

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Armillaria Root Rot
(*Armillaria spp.*)

Hosts

Armillaria root rot is a general name for a group of diseases caused by fungi of the genus *Armillaria*; most commonly *A. mellea* and *A. ostoyae*. In general they are pathogens of the roots and lower stems of both hardwoods and conifers and are important decomposers of dead trees.

Symptoms and Signs

The symptoms of Armillaria root rot often resemble many other diseases and disorders of trees such as drought, decline, Hypoxylon canker, Annosus root rot, and Phytophthora root rot. Growth reduction, chlorotic or scorched leaves, early fall coloration and/or premature leaf drop, branch dieback, wind-throw, and tree death are common above-ground symptoms. Conifers may produce large crops of undersized cones during decline. Trees are often affected in groups.

Armillaria causes cankers (lesions) on the inner-bark and outer-sapwood on the root-crown and lower stem. Cankers may expand slowly and eventually kill large roots; entire stems are not usually completely girdled, but large lesions may cause dieback or death. After a tree dies, the fungus colonizes and decays sapwood.

There are some very distinct signs of the *Armillaria* fungus used to confirm its presence. White mycelial fans (sheets of white fungal tissue) are often visible beneath the bark of cankers of rotted wood. Black or brown branched rhizomorphs (also fungal tissue) that resemble fine roots or shoe strings may also be visible beneath bark, on root surfaces, and may even extend into the soil. Rhizomorphs may be flattened when found beneath bark, but are cylindrical (< 1/32 inches in diameter) when found on the bark surface or in the soil. Golden-yellow mushrooms may be produced around dead or diseased trees in the fall. Many species of *Armillaria* are bioluminescent.

Life-Cycle

Stressed trees are highly predisposed to *Armillaria* root rot. *Armillaria* spreads via rhizomorphs, root to root contact, and airborne spores. Rhizomorphs are made up of densely packed fungal hyphae to form fine root-like structures. Rhizomorphs can grow through the soil (up to 8 feet per year) feeding on organic matter as they go, until they reach the roots of new trees. Rhizomorphs attach to tree roots and penetrate the bark by mechanical force and enzymatic degradation. Airborne spores are produced from golden-yellow mushrooms (honey mushrooms) that grow around the base of infected trees. Spores infect dead stumps and wounds on lower stems and exposed root tissue. The hyphae of a single fungus can spread great distances through the soil.

Management

Prevention is difficult; no practical treatment options are available. It is critical to maintain proper tree health. Select the proper tree species for the site; provide adequate water and fertilization if necessary. Remove diseased trees and infected root systems if possible.

Mycelial fans beneath the bark of infected trees is a key diagnostic

Rhizomorphs are responsible for tree to tree spread of this disease.

Armillaria tabescens fruiting bodies appear in the fall after significant rainfall.

Seiridium Canker
(*Seiridium* spp.)

Hosts

Seiridium canker is a destructive fungal disease on Leyland cypress. In the southeast, this disease is caused most often by the fungus *Seiridium unicorne*.

Symptoms and Signs

Branch dieback and foliage discoloration is one of the first noticeable symptoms of this disease. Chlorotic and necrotic foliage is most likely to appear in spring; however it can be seen at any time of the year. Upon close examination, branches exhibiting discoloration will have dark, elongated lesions called cankers. Seirdium cankers form on stems, branches, and in branch axils. They may be discolored dark brown to purple and are often accompanied by an extensive flow of resin.

Spore producing structures can be seen on the surface of cankers, as small, black dots with the aid of a 10X hand lends. These black fruiting bodies open during wet weather to release spores, called conidia.

Life-Cycle

The pathogen overwinters in cankers on diseased trees. Fruiting bodies with conidia are present throughout the year. Environmental stressors, like drought or ice injury, predispose Leyland cypress to infection. Most infections are thought to be initiated during wet weather by conidia. Spores can be spread via rain, overhead irrigation, and pruning tools. Twig and branch wounds are the common places for infections to occur. Following infection, canker development and dieback can take several years to develop, depending on environmental conditions. It is important to note that spore production is interrupted during hot, dry weather.

Management

Proper tree care is the best defense against seirdium canker in residential landscapes. Plant Leyland cypress trees at a minimum of 12 to 15 feet apart to ensure good air circulation between trees. Provide trees with adequate water (at least 1-2 inches per week below the entire drip line), and avoid over-fertilization. To reduce the spread of spores, avoid overhead irrigation or restrict it to early morning hours. Prune out branch cankers by making pruning cuts 3 to 4 inches below diseased tissue. Since spores can be spread via pruning tools, it is important to sterilize tools with a 10% bleach solution following the pruning of diseased limbs. Fungicides provide no control once an infection has taken place.

Oozing sap from seiridium canker. Dripping resin marks the location of a canker.

Branch and twig dieback symptoms of seiridium canker. Foliage discoloration is due to canker girdling of the branch.

Seiridium unicorne conidial spores. Conidia exude from fruiting bodies in cankers during wet weather.

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Pine Wood Nematode
(*Bursaphelenchus xylophilis*)

Hosts

This disease occurs mostly on non-native species of pine. In particular, Japanese black pine (*Pinus thunbergii*), Japanese red pine (*Pinus densiflora*), and Austrian pine (*Pinus nigra*) are highly susceptible.

Symptoms and Signs

The first symptom is wilting foliage. Wilted trees will turn yellow to brown within three months after becoming infested.

The pine wood nematode can only be identified under microscope magnification. Symptomatic branches will need to be sent to the NC Department of Agriculture Nematode Assay Section. Do not let samples dry out and submit them as soon as possible.

Life-Cycle

Longhorned beetles in the genus *Monochamus* have been shown to transmit the pine wood nematodes. These beetles are known as sawyers. The pine wood nematode is transmitted to new pine hosts during beetle feeding. In April and May, adult sawyers emerge from nematode infested trees, carrying hundreds of nematodes in their bodies. As the adult beetles feed on healthy pine shoots, the nematodes leave the sawyers and enter the new pine host through beetle feeding wounds. The pine wood nematode first colonizes the resin ducts of the tree and then moves into the water-conducting tissue, xylem. The nematode reproduces rapidly in the xylem, which leads to wilting and tree death.

Sawyers are attracted to dying or dead trees in which they can lay their eggs. The nematodes, by killing trees, are providing breeding areas for the sawyer beetles. Pupal chambers are created in the dead wood, where the sawyer beetles complete their life-cycle. In the pupal chamber, juvenile nematodes enter the bodies of young adult beetles just before they emerge from their chambers. These young adults fly away from the dead host carrying the nematodes in their bodies in search of healthy pine trees to feed on, repeating the life-cycle.

Management

Do not plant susceptible, non-native pine species. Remove and discard all diseased trees by burning, burying, or debarking. There are no chemical control options available.

Wilt symptoms on Austrian Pine (*Pinus nigra*).

Pine wilt nematode (*Bursaphelenchus xylophilus*).

Longhorned beetles like this southern pine sawyer, *Monochamus titillator*, have been shown to transmit pine wood nematodes.

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Hypoxylon Canker
(*Hypoxylon* spp.)

Hosts

Hypoxylon canker is a secondary disease of many hardwood species that affects trees that are already severely stressed by some other cause. Hypoxylon canker is caused by many Hypoxylon fungi, most commonly *H. atropunctatum* and *H. mediterranea*. Most common hosts are oaks (especially red oaks). Also found in hickory, maple, beech, sycamore, birch, elm, walnut, and many others.

Symptoms and Signs

Symptoms may initially resemble those of oak decline. Bud break may be delayed, leaves may be undersized, foliage may be chlorotic, scorched or wilted, and branches may begin to dieback from the top of the tree downward.

The easiest way to identify Hypoxylon canker is by the large spore-bearing mats (stromata) produced beneath the bark of infected trees. These stromata usually appear the year following drought (or other severe stress), but may appear within a few months. Stromata will grow in size and eventually rupture the bark; patches of sloughed off bark range from a few inches to many feet in size. In severe cases, almost the entire tree will lose its bark and be covered in the fungal mats. Stromata can vary in color from tan, brown, black or grey depending on the species. Trees die quickly if not already dead at the time of stromata production.

Life-Cycle

Spores of *Hypoxylon* fungi are everywhere. Even when little or no disease is present in the forest, the fungus is present as a wood-rotter and feeds on dead wood. Trees are most often infected at a very early age through small wounds and natural openings. It is believed that most oaks and other susceptible species have Hypoxylon infections, but disease does not develop until trees become severely stressed. When trees become water stressed, the *Hypoxylon* colonies begin to grow rapidly in the water-depleted sapwood and inner bark. The fungus attacks these tissues, forms stromata, and the bark is sloughed off. With little or no remaining functional vascular system, trees die quickly once the invasion begins. The fungus then invades the remaining wood; initially turning sapwood brown, it causes a yellowish-white decay with black zone lines.

Management

Few management options are available. Proper tree care is critical. Provide trees adequate water (at least 1-2 inches per week below the entire drip line), fertilizer (avoid nitrogen rich fertilizers), and room to grow with little competition from neighboring trees or understory. Add a thin layer of mulch (1-3 inches) around the drip line. Avoid planting susceptible species on dry sites.

Silver-gray stromata of *Hypoxylon* spp.

Fruiting bodies known as stromata turn brown to black or silver to bluish-gray depending on the *Hypoxylon* species causing the infection.

Mistletoe
(*Phoradendron* spp.)

Hosts

Mistletoe is a perennial, broad-leafed, evergreen plant that parasitizes many species of hardwood trees; most commonly oaks and hickories.

Mistletoe infestation on oak.

Symptoms and Signs

Heavily infested trees may be reduced in vigor, stunted, or even killed, especially if they are stressed by other factors.

The presence of green stems and thick oval shaped mistletoe leaves is the only reliable sign of an infestation. Identification of an infestation is easier to observe in the winter when all the leaves are off the host plant. Leafy mistletoe has opposite evergreen leaves, rounded growth habit, and reaches approximately 2 feet in width. Inconspicuous flowers produce small, sticky, whitish berries in the fall.

Life-Cycle

Mistletoe plants are either female (produce berries) or male (produce pollen). After fertilization, female plants produce sticky berries that are dispersed either by birds or by falling to lower branches. Mistletoe seeds germinate anywhere if environmental conditions are right, but they can only initiate infection if they stick to the bark of a suitable host. Once the mistletoe seed lands on a suitable host and germinates, it grows through the host bark and into the tree's water-conducting tissues, where root-like structures called haustoria develop. The haustoria absorbs both water and minerals from its host tree. Mistletoe leaves are capable of photosynthesizing their own food; this food is not shared with the host. As the mistletoe plant grows, the haustoria gradually extends up and down the inside of the infected branch. Female plants will eventually bloom, produce seed, and infect new hosts, repeating the life-cycle.

Evergreen clumps of mistletoe are readily observed on deciduous trees in winter when leaves are off the trees.

Management

Control is usually not necessary. Pruning out mistletoe is the most effective method of control. Infected branches need to be cut at least one foot below the point of mistletoe attachment, in order to remove all the haustoria. Mistletoe infecting a major branch or trunk where it cannot be pruned may be controlled by cutting off the mistletoe flush with the limb or trunk. Then wrap the area with black polyethylene to exclude light and prevent photosynthesis. It is important to remove mistletoe before it produces seed and spreads to other limbs or trees.

Mistletoe plants are parasitic plants capable of making their own food through photosynthesis.

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