Tree and Shrub Problems in Kansas:

Diseases, Insects, and Environmental Stresses

K-STATE Research and Extension

Kansas State University Agricultural Experiment Station and Cooperative Extension Service

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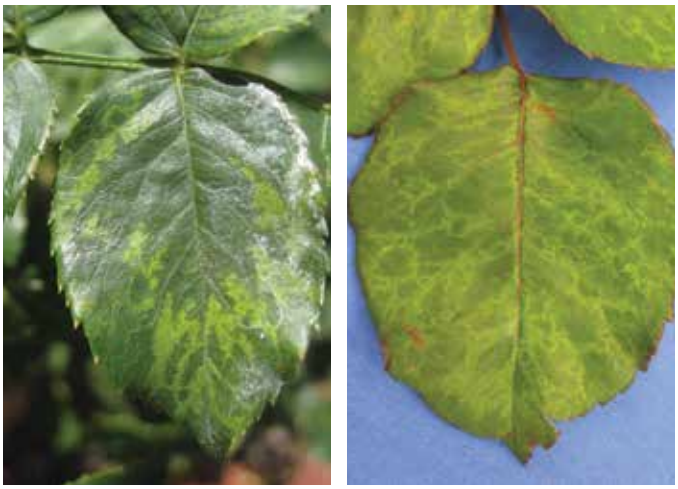

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Trees and shrub problems in Kansas: Diseases, insects, and environmental stresses

Purpose and scope of this guide

Trees and shrubs are subject to many environmental and site-related stresses (abiotic stresses), infectious diseases (caused by fungi, bacteria, viruses, and nematodes), and arthropod pests (insects and mites). Many of these problems cause only minor damage and do not require control measures, even though the damage may appear to be serious. Other problems can be severe, resulting in the death of individual or whole groups of plants, such as the loss of many American elms from Dutch elm disease and the loss of many pines as a result of pine wilt.

This guide has been developed for tree-care professionals, rural landowners, K-State Research and Extension Master Gardeners, homeowners, and others who manage or have an interest in trees and shrubs. It provides an overview of different tree problems followed by an extensive itemized list of specific diseases, insects, mites, and environmental/abiotic stress problems of trees and shrubs common in Kansas, information on how to identify those problems, and guidelines for management. Specific pesticide information is not included, since products and labels change frequently.

The introductory section discusses:

1) Environmental and abiotic stress problems of trees and shrubs
2) Diseases of trees and shrubs
3) Insect and mite pests of trees and shrubs
4) General pest management and plant health strategies for trees and shrubs
5) Pesticide use for disease, insect, and mite management in trees and shrubs
6) Diagnosing tree and shrub problems

Listing of specific pesticides is beyond the scope of this guide. There are other sources for pesticide information, including the Plant Disease Diagnostic Clinic and Insect Diagnostic Laboratory at Kansas State University (Manhattan, Kan.). Their contact information is listed in the "Diagnosing tree and shrub problems" section, on Page 18. The most important source of information about pesticides is the pesticide label itself. Pesticide applicators must read and understand the label before use. Persons using such products assume responsibility for their use in accordance with current label directions of the manufacturer. See the section "Pesticide use for disease, insect, and mite management in trees and shrubs" on Page 16 for further information.

Environmental and abiotic stress problems of trees and shrubs

Nonliving factors, such as unfavorable weather, mechanical injuries, soil issues, or fertility imbalances, cause abiotic stress problems. These problems also are called environmental stresses, abiotic disorders, abiotic diseases, noninfectious disorders, and physiological disorders. In contrast to "biotic" diseases caused by living microbial organisms or insects, abiotic problems are not caused by living organisms, and they do not spread from plant to plant.

Why are we starting with abiotic stress problems? Abiotic problems are common, and they can make trees and shrubs more susceptible to diseases and insects. When diagnosing tree problems, always consider abiotic factors as a component of the diagnosis. In addition, when selecting a tree or shrub for a given location, be sure to consider soil type, drainage, pH, fertility, shade/light conditions, and other site characteristics. Choose the right plant for the right place based on those factors. General tips for promoting tree and shrub health are described in a later section. Site factors should be the number one concern in the plant selection process: choose plants according to site conditions.

Some of the most common abiotic problems of trees and shrubs are described below. Many of these abiotic disorders frequently occur together and increase the plant's likelihood of eventual infestation by insect or disease pathogens.

Water and temperature problems

General drought stress

During drought, trees and shrubs do not receive adequate water to maintain necessary plant metabolism. Symptoms include wilt, leaf scorch (browning at leaf tips or margins), premature leaf shedding, fruit drop, and, in the case of young trees, transplant stress or death. New transplants and young trees with small root systems are most susceptible to moisture stress. Slow, deep irrigation at regular intervals throughout periods of prolonged dry weather (summer or winter) can help both young and mature trees. Note that prolonged periods of excessive water can cause similar symptoms, so be sure to evaluate the moisture conditions before taking action. Overwatering kills roots and can be as detrimental as insufficient watering.

Environmental scorch

The term environmental scorch describes necrosis (tissue death and browning) of leaves or needles. It can give a tree or shrub the appearance of being "burned." During dry, windy weather, transpiration (water loss) from foliage (leaves or needles) occurs more rapidly than the plant is able to take up water from the soil. The symptoms usually start at the tip (Figure 1a) or margins (Figure 1b) of the foliage and progress toward the middle and base of the leaf. Additionally, environmental scorch typically begins on the newest leaves first. Entire leaves may become dry. Scorch occurs on coniferous and broadleaf evergreens as well (Figure 2), including in the winter, which is called winter desiccation (see below). Providing adequate water can reduce scorch.

Along with drought, environmental scorch results from other factors, such as a poor root system, root or trunk injuries, girdling roots, or damaging chemicals in soil such as herbicides, salts, and excessive fertilizer. Avoid mechanical and chemical injuries to roots, which inhibit root water uptake. Plant trees and shrubs adapted to local conditions and water them regularly and deeply during dry weather. Appropriate use of mulch around trees and shrubs helps maintain even soil moisture (Figure 3a), but mulch should not be piled deeply or directly against the trunk (Figure 3b).

Winter desiccation

Winter desiccation (drying) is a common cause of injury to evergreens. Evergreens retain their leaves (needles of conifers or leaves of broadleaf evergreens) throughout the winter and continue to transpire water. If the soil is dry or frozen, the plant cannot replace water lost from the leaves, resulting in scorching (browning) of needle tips. See the discussion above on environmental scorch.

Winter injury/winter kill

Winter injury or winter kill is a common problem of both evergreen and deciduous trees and shrubs in Kansas. Individual branches or entire plants can die from low-temperature damage. The most obvious symptom is a failure to resume growth in spring. Sudden drops of temperature are more damaging than steady declines, particularly if they occur before cold acclimation or after de-acclimation. Fluctuating winter weather patterns can cause trees and shrubs to break dormancy. Trees and shrubs in active growth from warm, wet autumns and late summer fertilization are also more easily damaged. Several steps can be taken to minimize winter injury. Trees and shrubs should be watered thoroughly, but not excessively, in the fall before freezing weather sets in. Additional watering of conifers may be required during winter months if weather conditions are unusually warm and dry. Do not water when the ground is frozen.

Plant sensitive evergreens where they will be protected from direct winter sunlight and drying winds. Avoid using plant species that are not cold tolerant according to hardiness zone maps. Mulching prevents frost from penetrating deep into the ground and can help reduce winter injury. Do not fertilize trees in late summer or early fall because this could result in the production of succulent growth that is susceptible to winter injury.

Wet soils/poor drainage

Soil is composed of water, minerals, organic matter, and pore spaces (air spaces). The pore spaces contain oxygen, nitrogen, carbon dioxide, and other gases. Roots require oxygen to function. When soil is saturated or compacted (see below), the pore space is reduced, decreasing oxygen availability and compromising root health. Heavy clay soils and low areas have poor drainage, leading to reduced oxygen and unhealthy roots. This condition is sometimes called "wet feet." Symptoms include branch dieback, wilting, leaf yellowing (indication of nutrient deficiency as a result of poor root function), scorch, small leaves, and a gradual reduction in plant vigor. Some tree and shrub species are particularly intolerant of wet soils including sugar maple, white birch, redbud, spruce, red oak, yew, pines, juniper, and arborvitae. In addition to abiotic problems, overly wet soils also promote certain root diseases. Select the plant according to site; wet sites require plants that tolerate moist conditions.

Sunscald and frost cracks

Young trees with thin, smooth bark, such as maple or linden, are susceptible to sunscald damage. This injury usually occurs in late winter when tree trunks are exposed to sunlight and warm temperatures during the day followed by a sudden drop in temperature after sunset. Large, irregular or elongate sections of the bark on the southwest side of the tree are killed.

Frost cracks are longitudinal splits in the bark and wood, caused in part by old wounds and by differential contraction rates of the inner and outer wood in the trunk from exposure to temperature extremes. The trunks of young, thin-barked trees and shrubs on exposed sites should be wrapped or otherwise protected from direct or reflected sunlight during the winter months. Remove the wrap in the spring. The practices for preventing winter injury also may prevent frost cracks.

Transplant shock

Newly transplanted trees and shrubs can become stressed, and if not properly maintained may exhibit leaf scorch, leaf drop, and slow growth. Extensive root damage can occur during transplanting even with ideal care. Transplant shock can be reduced through proper site preparation, proper planting technique, and proper watering. Additional references should be consulted for details on appropriate planting methods. Transplanting in the fall or early spring allows roots to become established before the onset of hot, dry summer weather. Do not seed or sod turfgrass under the drip line of newly transplanted trees and shrubs because the grass competes with the tree or shrub for water and nutrients. Instead, apply mulch (such as compost, bark chips, or wood chips) 2 to 4 inches deep to help retain moisture (Figure 3a). Do not place mulch directly against the tree trunk (Figure 3b). Root systems are not fully established for several years after transplanting.

Soil, fertility, and pH problems

Soil compaction

In compacted soil, the soil particles are pressed closer together leading to reduced pore space and limited flow of water and air. This leads to reduced root health as described above in the section about wet soils. Trees and shrubs exhibit branch dieback and reduced vigor. Soil can be compacted by foot traffic or construction in urban settings. In rural settings, livestock traffic can lead to compacted soils. Clay soils are more prone to compaction than sandy soils. Wet soils are also more prone to compaction. Soil compaction is a primary cause of tree failure on new construction sites or following home renovations involving heavy equipment. During construction, heavy equipment should be kept away from tree and shrubs, at least out to the drip line.

Adding soil to a site

Most tree and shrub roots grow in the upper 18 inches of the soil profile and are sensitive to changes in the soil grade or depth. When a layer of soil is added around a tree or shrub, air movement is decreased resulting in anaerobic (low-oxygen) conditions. Water movement downward to the root zone may be decreased, causing reduced soil moisture, or the water table may rise contributing to anaerobic conditions. New roots do not develop well in the added layer of topsoil. The damaged roots are less effective at obtaining water and nutrients. Affected trees and shrubs may die within a few months, or they may decline slowly over a period of years. Symptoms include leaf yellowing, production of abnormally small leaves, premature fall coloration, poor leaf emergence, a thin crown, cankers, or epicormic branching or suckers along the trunk or main

branches. In later stages, wood decay and the associated decay fungi may develop. Another indication that soil fill may have occurred is lack of a root flare. A normal tree that has been planted correctly is wider or flared at the base as it goes into the soil (Figure 4a). A tree that has had soil filled in around it may lack a root flare (Figure 4b).

Removing soil from a site

With a majority of the root system in the top 18 inches, removal of soil from this area can result in significant damage to the tree or shrub by removal of the fine feeder roots that are required to uptake water and nutrients. The remaining fine feeder roots are closer to the surface and are subject to damage from drying, freezing, or overheating. Symptoms are similar to those caused by the addition of soil (described above): small yellow leaves, epicormic sprouts, branch dieback, decline, or eventual death.

Fertility and pH

Plants require certain nutrients for growth and development. Those nutrients come from the soil and from fertilizers (manufactured products as well as manures or composts) that are added to the soil. Fertility excesses and deficiencies are damaging, and some fertility problems can be mistaken for diseases. Some soils have high or low pH, influencing the availability of essential nutrients. For example, high pH (greater than 7.0) renders iron less available to some plants, causing yellowing known as iron chlorosis (see below). High soil pH is a common problem in western Kansas. A soil test can provide information on pH and nutrients as well as recommendations on how to remedy potential problems. Contact information for the Kansas State University Soil Testing Lab is provided on Page 18 (Diagnosing tree and shrub problems).

Iron chlorosis

Iron deficiency results in stunted, yellow (chlorotic) leaves with the leaf veins remaining green (Figure 5). Under severe iron chlorosis, leaves develop brown irregular spots. Trees under chronic iron deficiency may exhibit poor growth and branch dieback. Iron becomes less available as soil pH increases (greater than 7.0), and many areas of Kansas have high pH soils. Pin oak, sweetgum, and soft maple as well as many other trees and shrubs also are susceptible to iron chlorosis. Avoid planting trees and shrubs sensitive to iron chlorosis in high pH soils. An iron deficiency can be corrected in some cases with foliar sprays or trunk injections of iron-containing compounds, or by soil amendments containing iron sulfate; however, these procedures are laborious and some soils are hard to adjust, such as calcareous soils. A soil test can provide information on pH and nutrients as well as recommendations on how to remedy potential problems. Contact information for the Kansas State University Soil Testing Lab is provided on Page 18 (Diagnosing tree and shrub problems).

Girdling damage

Girdling roots

Roots tightly wrapped around the main trunk or other roots cause constriction, reducing the flow of water and nutrients in the xylem and phloem. Large branches on the same side as the girdled roots lose vigor and may eventually die. If a large lateral root girdles a significant portion of the trunk, the plant will become progressively more stressed over a number of years. The main leader may die back. Girdling roots are sometimes visible at the base of the tree (Figure 6a). Underground girdling roots are more difficult to detect, but if root flares are lacking or the trunk is flattened or concave on one side (Figure 4b), an underground girdling root may be present. Improper planting and poor production practices are the primary causes of girdling roots. Young trees that have grown too long in containers tend to have overgrown root systems that spiral along the walls of the container. If the roots are not trimmed or straightened during planting, root girdling can become a problem. Trees planted along city streets are particularly prone to the development of girdling roots. In some cases, a tree-care professional can alleviate the problem by removing a section of the root. Regular watering and fertilizing may be needed to improve plant vigor.

Other girdling injury

In addition to girdling roots, described above, girdling can be caused by wires (for example, from wire baskets around the root ball), rope, string, vines, and other materials that are wrapped around trunks, roots, or branches (Figure 6b). The flow of water and nutrients is reduced by constriction, leading to reduced vigor and dieback.

Chemical damage

Herbicide injury

Herbicides applied to lawns, gardens, roadsides, crop fields, or other sites may cause damage to trees and shrubs if improperly used. Soil sterilants used along driveways, fencerows, and ditches can be absorbed by tree or shrub roots many feet away from the trunk, resulting in extensive damage. Trees and shrubs also can be injured by airborne herbicide drift. Symptoms of

herbicide injury include yellowing or distortion of leaves, scorching of leaves, and branch dieback. Herbicides can cause gradual decline or rapid death. Following directions on the pesticide label can avoid most herbicide injury. Avoid excessive use of herbicides near trees and shrubs. If herbicide injury is suspected, determine which herbicide was applied, the application rate, and when the herbicide was applied, noting that some herbicides have an extended period of residual activity.

Salt injury

Injury to trees and shrubs from deicing salts is common in urban areas, particularly along sidewalks and roadways (Figure 7). Salt injury to roots occurs when deicing salts are washed into the root zone by precipitation, which leads to branch dieback, wilting, leaf yellowing, and leaf scorch. Salt injury also can occur on branches from direct contact of deicing salts, with twig dieback as a common symptom.

Gas leak

Natural gas leaks from an underground line are not directly toxic to trees and shrubs, but may negatively modify the growing environment of the soil by displacing oxygen. Multiple plant species may be affected in the vicinity of a leak. The soil may have a black color or an off-smelling odor indicating the presence of anaerobic conditions. Gas companies can use gas-detection meters to confirm the presence of a leak. An affected tree or shrub may not recover from a gas-related root injury. Soil aeration using an auger or compressed air may improve the condition of the soil before planting a replacement tree. Gas leak injury is rare but may be something to consider when evaluating tree decline.

Mechanical damage

Storm injury

High winds, heavy snow loads, hail, and ice storms can cause physical damage to trees and shrubs (Figure 8). The wounded areas are susceptible to infection by decay and canker-causing fungi. Trees and shrubs weakened by wood decay are particularly prone to branch damage or tipping over. Proper pruning after storm injury helps prevent decay. Trees may require inspection and evaluation by a professional after storm damage for defects. Some trees or shrubs may require removal to reduce risk.

Lightning

Lightning may strike a tree resulting in a dead strip of bark extending the length of the trunk, split or shattered bark (Figure 9), or major structural damage. In contrast, some strikes may run the length of the tree and kill the root system resulting in a slow death with no obvious immediate damage. Tall trees, trees growing alone in open areas, trees growing in moist soils, or trees growing along lakes and ponds are more susceptible to lightning strikes. Trees may exhibit immediate damage or may take some time to show signs of decline. A tree-care professional should evaluate severely damaged trees.

Equipment damage

Lawn mowers, weed trimmers, improper pruning techniques, and vehicle impact can damage trees and shrubs. These wounds are potential infection sites for wood decay fungi. Depending on the amount of damage, the plant may decline quickly or slowly over many years. Using mulch (Figure 3a) reduces the potential for injury from lawn mowers and weed trimmers by reducing equipment use next to the trunk. Mulch should not be placed directly against the trunk.

Excavation and construction damage

During construction, tree and shrub roots are often severed while excavating or trenching for utility lines, driveways, sidewalks, building foundations, and other structures (Figure 10). Damage levels depend on the extent of root breakage or removal. Loss of major roots leads to reduced water and nutrient uptake as well as a dieback of the major branches on the side of the root removal. Wounded roots are more susceptible to soil-borne pathogens. Depending on the amount of damage, trees may decline quickly or slowly over many years. If there is significant root damage, the tree may need to be evaluated by a professional for potential removal to prevent complete tree failure.

Animal damage

Animals cause physical injury to trees and shrubs by weakening the plant and providing entry sites for plant pathogens. In some years, squirrels chew strips of bark off twigs and small branches, leading to branch dieback. They also can clip the ends of branches. Deer feed on young branches and stems, removing the growing point, which leads to unattractive, bushy growth. Male deer rub antlers on trees and shrubs, breaking branches and damaging bark. Sapsuckers/woodpeckers cause damage by creating holes when they feed on insects just below the bark. Rabbits and voles feed on the base of young, thin-barked trees and shrubs, causing girdling. Trunk protection or cages may be required. There are also animal repellents available that can be sprayed on plants for short-term protection.

Diseases of trees and shrubs

Plant pathogens that penetrate and colonize plant tissue cause many tree and shrub problems. Many tree and shrub diseases lead to only minor aesthetic damage, with little harm to the plant's overall health. Some diseases cause temporary or permanent damage to a plant's vigor, whereas a few diseases are capable of killing trees or shrubs.

The most common tree and shrub pathogens are fungi. Fungi can cause leaf spots, wilting, cankers, root rots, and many other symptoms. Most fungi produce spores that can be spread by wind, rain, or in soil to start new infections. Many fungi produce their spores in reproductive fruiting structures. Some fungi also produce special structures for survival during winter or for long periods in the soil.

Along with fungi, other microbial organisms, including bacteria, nematodes (microscopic worms), and viruses are capable of causing plant diseases. Bacteria thrive in wet conditions. They can cause leaf spots, cankers, galls, and other diseases. Viruses spread plant to plant in different ways including by insects and on sap on infested pruning tools. The main nematode problem on trees and shrubs in Kansas is the pinewood nematode, which causes pine wilt.

Tree and shrub diseases can be divided into different categories. Several common categories of plant diseases are described below, with general comments on biology, symptoms, and management: (1) foliar diseases such as leaf spots and anthracnose, powdery mildew, and rusts; (2) wilts; (3) cankers and branch dieback/twig blight; (4) crown gall; (5) wood decay; (6) root rot; (7) wetwood; and (8) viruses. Comments on specific diseases are provided in the table following this introductory chapter, starting on Page 20.

Foliar diseases

Leaf spots and needle blights

Leaf spots are localized infections on broadleaf foliage or needles. In Kansas, fungi cause most leaf spots. Common examples of fungal leaf spots include ash leaf spot (Figure 11), apple scab (Figure 12), Septoria leaf spot of dogwood (Figure 13), black spot of rose (Figure 14), and Dothistroma needle blight of pine (Figure 15a). Bacterial leaf spots of trees and shrubs are rare in Kansas. Leaf spots seldom cause extensive damage to deciduous trees, especially if the spotting occurs late in the season when the tree or shrub has produced and stored adequate carbohydrates. Since conifers retain their needles and use them for photosynthesis for several years, the loss of needles is more damaging.

Fungi that cause leaf spots usually produce spores that are spread by wind or rain splash. Most leaf-spot causing organisms survive on infected plant debris and require moisture on the leaf surface for a number of hours to infect the host. Therefore, cultural practices such as sanitation (removing infected debris, raking leaves in fall) and providing good air movement (such as thinning an overly crowded windbreak) reduce the incidence of these diseases. Avoid wetting the foliage with overhead irrigation. When establishing new plantings, plan ahead to avoid crowded conditions. Occasionally, fungicide sprays may be useful to protect trees and shrubs from severe infection. Resistant varieties are available for some leaf spotting diseases.

Anthracnose diseases

Anthracnose is a general term used to describe a group of plant diseases caused by various fungi that infect leaves and twigs in spring. Anthracnose fungi survive the winter in infected twigs and fallen leaves. They cause new infections during wet spring weather. In Kansas, anthracnose is most common on sycamore, ash, maple, oak, and walnut. The anthracnose fungi are host specific, meaning that (for example) the fungus that causes anthracnose on oak is different from the one that causes anthracnose on maple. Symptoms include irregular foliar blighting and spotting, often along the major veins (Figures 16, 107, and 108), premature leaf shedding, and/or twig blighting (Figure 17). Repeated killing of young twigs results in abnormal branching and gives the tree a ragged appearance. Anthracnose can be confused with herbicide injury, environmental scorch, or frost injury, especially during spring weather fluctuations.

Although anthracnose diseases are unsightly, they do not kill or weaken the plant. In particular, large, mature trees tend to recover rapidly if properly maintained. The arrival of warm, dry summer weather after spring rains speeds the recovery process as the tree produces more foliage. Fungicides are rarely needed. Fungicides are available to prevent anthracnose, but they must be applied during the critical infection period in the spring. The typical recommended timing to initiate foliar applications is at or just before bud break. Fungicide applications later in the season have minimal effect. Some fungicide injection products are available for certain anthracnose diseases. The cultural

practices described above for general leaf spots also can reduce anthracnose.

Powdery mildew

Powdery mildews are common foliar diseases that appear as a white, powdery growth on the surface of leaves. The fungus may be visible as small, discrete colonies (Figure 18a) or it may grow on large portions of the leaf surface (Figure 18b). The fungus absorbs nutrients from the leaf, reducing the plant's carbohydrates, and the fungal colonies may be considered unsightly. Powdery mildews rarely cause significant damage to trees and shrubs in Kansas. If infection is severe, the reduced carbohydrates can result in a weakened plant that may be more susceptible to winter injury. Powdery mildews are caused by many different, but related, species of fungi. For example, powdery mildew on rose (Figure 18a) is caused by a different fungal species than powdery mildew of lilac (Figure 18b). Ash, barberry, oak, and many other trees and shrubs also are susceptible to various powdery mildews.

Rusts, including cedar apple rust, hawthorn rust, and quince rust

Rusts are named for the orange, rust-colored spores and fruiting structures that they produce. Like powdery mildews, rusts are fairly specific to the plants they infect. For example, the fungus that causes ash rust (Figures 19 and 20) is different from the rust that infects rose (Figure 21). Some rust fungi alternate between two hosts, such as cedar-apple rust. Cedar apple rust, hawthorn rust, and quince rust are common in Kansas and are described below. Other related species have been reported on rosaceous hosts in other states but have not been detected in Kansas.

Cedar apple rust is caused by the fungus *Gymnosporangium juniperi-virginianae*. The fungus produces several life stages that alternate between apple (and related species) and junipers. Some junipers are called Eastern red cedar, hence the name "cedar" apple rust. On juniper, the disease develops as hard, brown galls ½ to 1 inch in diameter. During wet weather in spring, the galls produce orange horn-like tentacles that are about ¾ to 1 inch long (Figure 22). The horns produce a spore type that infects the other (apple, crabapple, etc) host. The galls are productive for only 1 year, though the dead galls may persist on the tree. On apple, leaves develop yellow-orange spots on the upper leaf surface (Figure 23a) and cup-like projections on the lower surface. The cups produce another spore type that infects juniper, completing the cycle. The disease does not reduce the health of infected junipers but can cause major defoliation of susceptible crabapples (and relatives), reducing photosynthesis and weakening the tree. Resistant varieties of some types of apple and crabapple are available.

Hawthorn rust is similar to cedar apple rust and is caused by the fungus *Gymnosporangium globosum*. Like cedar apple rust, it infects junipers, but the alternate hosts include hawthorn, apple, crabapple, serviceberry, quince, and pear. On juniper, the disease produces galls and orange horn-like structures (Figure 24), but they are smaller, ¼ to ½ inch in diameter, than cedar apple rust galls and they persist for multiple years. Foliar symptoms of hawthorn rust on the apple hosts are similar to cedar apple rust, with yellow-orange spots on the upper leaf surface (Figure 23b) and cup-like structures on the lower surface. Like cedar apple rust, hawthorn does not seriously affect junipers but can cause serious defoliation of the apple hosts.

Quince rust is the third common rust from this group in Kansas, and it is caused by the fungus *Gymnosporangium clavipes*. On juniper, quince rust does not produce galls with horn-like projections. Instead, it causes swelling of twigs, with spores produced in orange cushions that are swollen and slimy when wet (Figure 25) and crust-like when dry (Figure 26). On juniper twigs, the disease can be active and produce spores for 4 to 6 years, and affected twigs eventually die. Furthermore, unlike cedar apple rust and hawthorn rust, quince rust tends to occur on twigs (Figure 27), thorns, and fruits (Figure 28) of hawthorn.

Wilt diseases

Wilt pathogens colonize the water-conducting vessels in plants. The three most common and serious wilt diseases of trees in Kansas are Dutch elm disease, Verticillium wilt, and pine wilt.

Dutch elm disease

Dutch elm disease is caused by the fungi *Ophiostoma novo-ulmi* and *Ophiostoma ulmi.*

Symptoms include yellowing, browning, and wilting of leaves on a branch or several branches, leading to a "flagging" effect (Figure 29), which often becomes apparent during the first summer heat. Infected trees may die within a few weeks or survive for a year or more. Affected branches develop a brown discoloration of the sapwood just beneath the bark layer (Figure 30). The fungus is spread from tree to tree by bark beetles and also can move between trees through root grafts.

Prevention, scouting, and sanitation are critical for managing this disease. Early detection of the disease is important. Trees showing more than 5 to 10 percent crown symptoms seldom can be saved and should be removed immediately. Root grafts between healthy and diseased elms should be disrupted by mechanical trenching before the diseased tree is removed to prevent spread through roots. All diseased elm wood should be burned or buried immediately. The wood should not be stored for firewood use unless the bark is removed. Systemic fungicide injections may be used to prevent infection or to treat high-value trees already infected, but only if disease is detected early, when fewer than 5 percent of the crown exhibits symptoms. Fungicides are not a substitute for sanitation, and they are not always effective. There are new varieties of elms available with resistance to Dutch elm disease, and these should be considered in new plantings.

Verticillium wilt

Verticillium wilt, caused by the soilborne fungus *Verticillium dahliae,* primarily occurs in late spring. Common hosts include catalpa, redbud, smoketree, maples, and elm, but many more species also are susceptible. The fungus infects through roots, therefore it is important to avoid wounding the roots or root collars.

Affected plants exhibit rapid wilting and drying of leaves in a portion of the tree (Figure 31) or throughout the entire crown. In addition, leaves may turn yellow. Branch dieback also can occur. Vascular discoloration (brown streaking) may be visible when viewing cross sections of cut branches (Figure 32) or when bark is removed. Symptoms generally progress from lower parts of the tree upward. Infected trees and shrubs can suddenly die, but they sometimes survive several years or more with slow decline over time.

Water any trees showing symptoms of Verticillium wilt unless there is sufficient soil moisture. Dead branches should be pruned. If a site is known to have a history of Verticillium wilt, select a nonsusceptible plant when replanting, such as conifers, hackberry, dogwood, hawthorn, honeylocust, sycamore, sweetgum, or crabapple.

Pine wilt

Pine wilt is caused by the pinewood nematode, *Bursaphelenchus xylophilus*, a microscopic worm. The nematode is spread from tree to tree by the pine sawyer beetle (*Monochamus* spp.) (Figure 77). Needles of infected trees turn gray-green then brown, and they remain on the tree. Branches become dry, lacking sap, and break easily when bent. Within a few weeks to a few months the entire tree usually dies (Figure 33). Sanitation is important for managing this disease. Infected trees should be cut to the ground, and all wood should be either chipped or burned before April 1. Pine wilt is common in Scots and Austrian pines but occurs in other pine species.

Cankers

Cankers are caused by fungi and bacteria that infect tissue under the bark. Canker symptoms include sunken, cracked, or discolored bark, such as occurs with Thyronectria canker of honeylocust (Figure 34). Fungal fruiting structures may be visible on the bark, such as Endothia (Figure 35) and Biscogniauxia canker (Hypoxylon canker) (Figure 36) of oak. In canker diseases, the wood in the affected area is brown and dead, visible when the bark is removed (Figure 37). Fire blight is a bacterial disease of crabapple, pear, and related species that can cause branch cankers.

Canker diseases are most common in trees and shrubs stressed by winter injury, drought, freeze/thaw cycles, hail, insect boring wounds, or pruning wounds. Several canker fungi are known to survive latently in plant tissue, without causing symptoms, and then colonize rapidly when the tree or shrub is stressed.

The risk of cankers can be reduced through proper care including appropriate irrigation, pruning (while minimizing wounds), fertilization, protection from winter injury, and other general practices. Some cankers can be managed by pruning out affected branches. Fungicides are not effective against cankers.

Crown gall

Crown gall is caused by a soilborne bacterial species, *Agrobacterium tumefaciens*. Galls normally develop near the soil line, although in some species, galls occasionally develop higher on the stem or on branches. The galls first appear whitish or creamy colored but later turn dark and woody (Figure 38). Galls disrupt the normal flow of nutrients and water, reducing plant growth. In Kansas, euonymus, rose, cottonwood, willow, apple, peach, and cherry are commonly affected, but many other species also are susceptible to crown gall.

Once the disease occurs, there are no curative treatments. The best means of managing crown gall is to prevent the introduction of the pathogen. Carefully inspect all plants for galls before purchasing or planting. Any plants with

galls should be discarded immediately. The crown gall bacterium attacks susceptible tissues through wounds, so minimize injury to tree roots during planting and cultivation. The bacterium can survive many years in the soil. Do not replant with susceptible species in sites where crown gall has been a problem.

Wood decay

Wood decay reduces the strength of branches, trunks, and roots, which poses a risk to structures, cars, or people, especially during windy weather or ice storms. Trees and shrubs with decayed roots are prone to falling due to loss of root anchoring strength.

Wood decay is the progressive deterioration of the cell wall substances (lignin and cellulose) of wood, caused primarily by fungi that produce enzymes capable of degrading those substances. Wood decay colonizes through wounds, branch stubs, and other compromised sites. Trees and shrubs have natural defense mechanisms that may "wall-off" (compartmentalize) the decay process to a certain portion of the plant, but this barrier may be breached with additional wounding or injury. Once the decay process has been initiated, it is difficult to control.

Decay is often invisible from the outside except where wounds or injuries have removed the bark. In those areas, symptoms of wood decay include soft, spongy, discolored, or crumbling wood (Figure 39). The presence of conks or mushrooms, the reproductive structures (fruiting structures) of wood-rotting fungi, can also indicate decay (Figure 40) as well as other types of macroscopic fungal growth (Figures 41a and 41b). It is common, however, for decay to occur without any fungal growths visible. Other symptoms of decay include hollow cavities, cracks, swellings in the trunk or branches, or general decline.

There are no "cures" for wood decay. Wood decay can be prevented by avoiding wounding. Pruning cuts should be made when branches are small to minimize wound size. Additional resources are available for details on appropriate pruning techniques.

Routinely inspect trees and shrubs for indications of decay. A trained tree-care professional should evaluate trees with conks, mushrooms, or other symptoms of decay. A certified arborist should remove trees that pose a risk to people, structures, or vehicles.

Phytophthora and Pythium root rots

Roots can be infected by wood decay fungi as described above. They are also susceptible to several additional root infecting organisms. *Phytophthora* root rot is a "water mold" (fungus-like organism) that affects trees and shrubs in the landscape, especially in sites with poor drainage. *Pythium* is another water mold that sometimes occurs in the landscape but is more common in nurseries and flower beds. Affected roots do not effectively acquire water and nutrients, which leads to wilt stress, nutrient deficiency, branch dieback, and general plant decline. The roots may be dark or mushy, with a lack of small feeder roots. To reduce problems with *Phytophthora* and *Pythium* root rots, avoid planting in sites with poor drainage, improve drainage in existing sites, and avoid excessive irrigation.

Wetwood

Wetwood also is called bacterial wetwood, bacterial slime, or slime flux. Symptoms of wetwood include the dripping or oozing of liquid or slime from cracks or wounds, which leaves a stain on the bark (Figure 42). Wetwood is common in elm, cottonwood, maple, mulberry, oak, willow, and sycamore. In general, wetwood does not pose any significant threat to landscape trees. Numerous species of bacteria have been associated with wetwood. Alcoholic flux is another condition in which microbes ferment sap. This process produces gas and alcohol, which develop into foamy exudates (Figure 43). Alcoholic flux is common on sweetgum, willow, elm, and oak, especially when trees are stressed.

Viruses

Viruses are tiny microbes spread by insects, sap transfer on infested tools, and grafting. They are not common in trees and shrubs, but there are several that occur in Kansas. Viruses cause a variety of symptoms including ringspots, mottling/mosaic coloration (Figure 44a), and line patterns (Figure 44b). Viruses also can cause distorted growth, such as the excessive thorniness associated with rose rosette (Figure 45a) and discoloration (Figure 45b). Viruses are systemic in plants, meaning the plant is infected for life. There are no cures for viruses. Infected plants should be removed and destroyed immediately to prevent further spread.

Insect and mite pests of trees and shrubs

Most insect pests associated with forest and urban ecosystems cause relatively minor damage to established trees unless populations reach outbreak proportions, in which case, there may be acute (short-term) or chronic (long-term) damage to trees and shrubs. It is important to understand the factors responsible for insect pest populations causing tree damage. First, abiotic (nonliving) factors such as weather (storms), over-crowding (competition), improper pruning, soil compaction, nutrient deficiencies, moisture availability, and aging may result in stress. Those factors are described in the section on abiotic disorders. Any type and/or level of stress results in trees and shrubs being more susceptible to various insect pests. Trees not experiencing any type of stress are able to defend themselves primarily through the production of chemicals such as oleoresin (a mixture of monoterpenes and resin acids), which provides defense against attacking adult bark beetles.

Endemic insect pests are either commonly native to an area or have been established for some time, and are widely distributed. They are mainly a concern when extreme environmental conditions persist such as high temperatures and lack of moisture, resulting in trees experiencing stress; thus compromising their ability to defend themselves. Population fluctuations or cyclic patterns may occur from year-to-year, depending on environmental conditions and the abundance of natural enemies such as parasitoids, predators, and pathogens, which may naturally regulate insect pest populations. Extreme weather, harvesting, and forest fires also can reduce populations of these insect pests by causing either direct mortality (death) or eliminating essential food sources or habitats.

Exotic insect pests have been inadvertently or accidentally introduced into the United States from other countries and invade new ecosystems in the absence of their typical natural enemies (e.g., parasitoids and predators). They can migrate within a short period of time. Some exotics may be specialists (attacking one type or genus of tree) or generalist, in which case, they may attack many kinds of trees. With no prior exposure to such insects, trees and shrubs may lack natural defenses, thus increasing their susceptibility. The major exotic insects that are a potential threat to forest and/or urban ecosystems of Kansas are the emerald ash borer (*Agrilus planipennis*) and the Asian longhorned beetle (*Anoplophora glabripennis*).

Insect feeding behavior

Insect pests differ in their ability to cause tree and shrub damage, which is associated with their feeding behaviors. The typical feeding behaviors of insect pests of forest and urban ecosystems are affiliated with chewing, piercing-sucking, and boring. The following sections list and describe the potential insect and mite pests of forest and urban ecosystems in Kansas based on their feeding behavior.

Chewing insects

Chewing insects such as beetles, caterpillars, grasshoppers, and sawflies physically remove plant tissue including leaves, twigs, and flowers. Wood-boring beetles are a special type of chewing insect and are discussed in a separate section. Below are descriptions of some of the common chewing insects.

Beetles

Adult beetles (order Coleoptera) typically have a hardened, outer-covering that protects the forewings. Larvae are usually soft-bodied and may vary in color depending on the beetle species. The adults feed on aboveground plant parts (e.g., leaves and stems) whereas, depending on the beetle species, larvae may feed on belowground plant parts (e.g., roots) or aboveground plant parts (e.g., leaves and stems).

Elm leaf beetle (*Pyrrhalta luteola*) adults are ¼ inch long, and yellow to dull-green, with a black stripe on each wing cover extending the entire length of the abdomen. There are distinct black spots on the head and thorax (Figure 46). Larvae are ½ inch long, yellow in color with two lines of black spots on the back (Figure 47). Apply contact insecticides at the first appearance of both adults and larvae, which may be found feeding simultaneously. Thorough coverage of both the upper and under sides of leaves is essential.

Japanese beetle (*Popilla japonica*) adults are ⅜ to ½ inch long, metallic green with coppery-brown wing covers. There are white tufts of hair at the end of the abdomen (Figure 48). Adults are present and active for 30 to 45 days, feeding continuously on leaves and flowers. They feed, primarily between leaf veins, resulting in leaves appearing lace-like or skeletonized. Adults also chew holes in flower buds and feed extensively on the petals of open flowers. Japanese beetle adults tend

to congregate in large numbers on plants. Damage can be severe if beetles reach high numbers. In those cases, apply contact insecticides when adults are active. It is important to note that multiple applications will be required.

Black vine weevil (*Otiorhynchus sulcatus*) adults are ⅜ inch in length, black, and the body is covered with patches of fine yellow hairs (Figure 49). Adults have a short, snout-shaped mouth, which is used to create characteristic notches on plant leaves during feeding (Figure 50). These notches are typically, but not always, located on leaf margins. Black vine weevil adults cannot fly. Adults are typically active at night and hide in debris or under plant containers during the day. Adults feed on foliage and primarily affect the aesthetic appearance of plants. The larva (Figure 51), which feeds on roots, is the life stage that can cause substantial plant damage. As such, insecticides should be applied to the soil to prevent larval damage.

Caterpillars

Caterpillars are the larvae of butterflies and moths (order Lepidoptera). They have soft bodies, hardened head capsules, and several pairs of fleshy legs called prolegs.

Bagworms (*Thyridopteryx ephemeraeformis*) create a small silk, bag, or case, covered with material from the host plant. Young caterpillars are ⅛ to ¼ inch long (Figure 52). Bagworms hatch over a month-long period. Older or mature caterpillars and their bags are 1 to 2 inches long (Figure 53). Females never develop into adult moths because they lack eyes, wings, legs, and antennae. Females remain inside the bag, producing eggs before dying. Males, however, transition into black moths with clear wings that are 1 inches long, and emerge from the bottom of the bag, dispersing to mate. Bagworms feed on a wide range of evergreen and deciduous trees and shrubs including arborvitae, cedar, white pine, elm, honeylocust, maple, oak, and poplar. Bagworms can cause substantial damage if they reach high numbers. Contact or stomach poison insecticides may be used to deal with extensive infestations. Removing female bags by hand in the winter may be effective in reducing caterpillar populations the following season.

Eastern tent caterpillar (*Malacosoma americanum*) builds nests (tents) that are initially 1 to 2 inches in length and width, and located in the crotches of twigs of various trees in the Roseacae family including hawthorn, cherry, plum, and crabapple (Figure 54). Full-grown caterpillars may be 2 inches or more in length, with a black head. The body is black with a white stripe extending down the back and a series of bright blue spots between yellow lines (Figure 55). Adult moths are 1 inch long and red-brown with two white stripes or wavy bands extending across each forewing. Physically removing or disrupting the nest early in the spring avoids having to use a contact or stomach poison insecticide.

Fall webworm (*Hyphantria cunea*) caterpillars are yellow-green or brown with black spots. Mature caterpillars are about 1 to 1½ inches long, with orange-yellow or black tubercles on the body. They have tufts of long, gray, silken hairs on the body (Figure 56). The head capsule varies from red to black. Caterpillars build large, protective nests or webs that are typically found on the ends of branches. They hide in large groups in these webs (Figure 57). The adult moths are 2 inches long, with the forewings containing brown spots, and small red-orange markings at the base of the front legs (Figure 58). Fall webworm caterpillars feed on birch, cherry, elm, hickory, walnut, willow, and other various shade trees and shrubs. Prune out localized nests or webbing and dispose of immediately. Use a rake to disrupt nests, which allows birds to feed on the caterpillars.

Grasshoppers

Adult grasshoppers (order Orthoptera) are generally 1 to 2 inches long (Figure 59). They vary in color from brown, red, yellow, to green depending on the species. Grasshoppers have modified, long hind legs that are adapted for jumping. Grasshoppers tend to feed during the daytime creating ragged holes in plant leaves (Figure 59). Many species of grasshoppers attack a variety of tree and shrub species. In most cases, the feeding damage from grasshoppers is cosmetic. Grasshoppers are difficult to control with insecticides due to their migratory behavior and the adults possess a hardened, waxy cuticle that reduces insecticide penetration.

Sawflies

Sawflies (order Hymenoptera) resemble caterpillars; however, sawfly larvae have prolegs on every abdominal segment whereas caterpillars lack prolegs on some segments In addition, caterpillar larvae have hairs or crochets on their feet, which are absent on sawfly larvae.

European pine sawfly *(Neodiprion sertifer)* adults resemble wasps. The female is orange, whereas the male is black (Figure 60). Both are 5/16 inch long. Full-grown larvae are approximately ¾ to 1 inch in length, gray-green with a black head and legs. A single, light-colored stripe extends down the back with two light green stripes

and one dark green or black stripe located on each side of the body. Larvae feed in groups on previous years' needles and may consume all the needles on a single branch. The larvae will feed on different pine species including mugo, Scotch, red, jack, and Austrian pine. Contact insecticides may be used as soon as the larvae are present in early spring. In addition, larvae can be removed by hand and placed into a container of soapy water.

Piercing-sucking insects and mites

Insects such as aphids, leafhoppers, and scales (in the order Hemiptera) feed in the vascular tissues of plants including the xylem (water-conducting tissues) and/or phloem (food-conducting tissues) withdrawing plant fluids with their stylet-like mouthparts. Plants fed on by piercing-sucking insects may exhibit symptoms such as stunting, leaf yellowing or chlorosis, wilting, and distortion of new growth. Certain mite species also have piercing-sucking mouthparts but do not feed in the xylem or phloem. Instead, they feed in the palisade or spongy mesophyll cells removing the green pigment (chlorophyll) from plant leaves.

Aphids

Aphids, in general, are 1/25 to 1/8 inch long, soft-bodied, pear-shaped, with two tubes called cornicles projecting from the back of the abdomen (Figure 61). The color of aphids varies, depending on the host plant they are feeding on and aphid species, from brown, green, red, yellow, orange, or black. Aphids use their piercing-sucking mouthparts to remove plant fluids from terminal growth and leaf undersides, which may cause leaf curling or distortion. During the feeding process, aphids produce honeydew, which is a clear sticky liquid that serves as a growing medium for black sooty mold fungi. The black sooty mold fungal growth is typically the first symptom that is noticed. Ants may be present along with aphids because ants feed on the honeydew excreted by aphids, move aphids from plant-to-plant, and protect them from natural enemies (e.g., parasitoids and predators). Contact or systemic insecticides may be used against aphids. In addition, forceful water sprays are effective in quickly removing aphids from trees and shrubs.

Leafhoppers

Leafhoppers are approximately 1/8 inch long, slender, and wedge-shaped (Figure 62). They are commonly yellow to light green although this may vary depending on the species. The wings are held roof-like over the body. Leafhoppers use their piercing-sucking mouthparts to withdraw plant fluids causing "stippling" of plant leaves (Figure 63), which is similar to the damage caused by twospotted spider mite feeding. Feeding by leafhoppers also may result in leaf distortion, chlorosis, plant stunting, curling of leaves, leaf yellowing, and leaf browning or necrosis. In addition, certain leafhopper species can vector diseases such as aster yellows. Leafhoppers are difficult to control with contact insecticides because they are highly mobile.

Lace bug

Adults are distinguishable and quite attractive. They possess lacy, clear, shiny wings that are held flat over the body (Figure 64). Adults are 1/8 to 1/4 inch long, and tend to not fly but move sideways when disturbed. Females may lay between 20 to 50 eggs during their lifespan on the underside of leaves. Eggs are black and with a long, cylindrical shape, similar to a wine flask. The eggs hatch into shiny, black nymphs with spines located on the periphery of the body (Figure 65). Lace bugs feed on the leaf undersides with their piercing-sucking mouthparts, withdrawing plant fluids from individual leaf cells, causing the upper leaf surface to appear light yellow or mottled, stippled and/or bleached (Figure 66). The damage is similar to that caused by the twospotted spider mite and leafhoppers; however, lace bugs leave black, tar-spot-like droplets of excrement on leaf undersides whereas both the twospotted spider mite and leafhoppers do not. Lace bugs, in general, will not severely damage plants although extensive populations may reduce aesthetic appearance. Contact insecticides may be used; however, thorough coverage of the leaf undersides is important and may be impractical for large plants.

Scales

Scale insects can be divided into two groups: soft or bark scales and hard or armored scales. Soft scales are flattened, convex, and oval or globular in shape, and produce a waxy covering. Hard scales appear circular or rounded in shape, and produce a hardened covering. Another way to distinguish between the two scale groups is that soft scales produce honeydew, a clear sticky liquid, and hard scales do not.

Pine needle scale (*Chionaspis pinifoliae*) females are elongated, approximately 1/16 to 1/8 inch long and white with a yellow portion attached, which tapers to one end. First and second instar nymphs are narrow and yellow. Males possess a small, rectangular, white covering. Pine needle scale overwinters as tiny red eggs located underneath parent (mature) scales. Nymphs are flat and yellow.

Contact insecticides may be used but should be applied as soon as crawlers are active. Scales are susceptible to natural enemies such as parasitoids; however, these may not kill enough scales to prevent damage.

Obscure scale (*Melanaspis obscura*) is ⅛ inch long and dull gray to black (Figure 67), which allows them to blend in with the bark of host trees such as oaks. Black shed skins are attached to the covers. Crawlers are typically active from July through September. Obscure scale primarily attacks oaks, but can be found on willow, maple, crabapple, and hickory. Contact insecticides must be applied as soon as eggs hatch and crawlers are active. After this, it is too late to initiate any control strategy. Maintain proper plant health by providing sufficient water and applying mulch around the base of plants. Removing scales from the trunk by scraping may be effective.

Pine tortoise scale (*Toumeyella parvicornis*) adults are approximately ⅙ to ¼ inch in diameter and hemispherical in shape. Females are red to light brown, with dark-brown to black markings (Figure 68). Males are somewhat flattened, smaller, and white in color. Pine tortoise scale produces copious amounts of honeydew, which is a clear, sticky liquid. Crawlers may be active from mid-June through early July. Contact insecticides may be used but should be applied as soon as crawlers are active. Scales are susceptible to natural enemies such as parasitoids; however, these may not kill enough scales to prevent damage from occurring.

Oak kermes scale (*Kermes pubescens*) ranges from ⅛ to ¼ inch in length and is lightly mottled brown (Figure 69). They are primarily located at the base of small twigs. Old female scales may be black and globular in shape with hard-shelled coverings that may resemble certain oak galls. Crawlers are small and are similar in appearance to other scale crawlers. In general, this scale will not kill plants, but heavy infestations may reduce aesthetic appearance. Prune out heavily infested branches or twigs. Contact insecticides should be applied when crawlers are active.

European elm scale (*Gossyparia spuria*) adults are ¼ to ⅜ inch long, oval in shape with a brown shell encircled by a white waxy substance (Figure 70). They are commonly located on branches or twigs and at the junctures where branches connect. The crawlers, which may start appearing in late June, are yellow and may be found in cracks and crevices in the bark. European elm scale primarily feeds on American and other native elms. Prune out localized infestations. Contact insecticides including horticultural oils may be applied when crawlers are active during the season.

Euonymus scale (*Unaspis euonymi*) adult female covers are dark brown, convex, and oyster shell-shaped. They are ⅛ to ¼ inch in length. Male covers are white and somewhat smaller than females (Figure 71). Crawlers, which are orange, resemble small yellow spots that move around on stems and leaves. The females are typically located on the stems; males are predominantly present on the underside of plant leaves. Euonymus scale overwinters as a mated female on plant stems. Euonymus scale feeds on evergreen euonymus, holly, privet, and pachysandra. Prune out heavily-infested branches and dispose of immediately. Apply a contact insecticide such as horticultural oil when crawlers are active during the season.

Lecanium scale

Lecanium scales, depending on the species, are ⅛ to ½ inch long. One common species is the European fruit lecanium (*Parthenolecanium corni*), which attacks many trees and shrubs. Females are hemispherical in shape and light to dark brown in color with mottling patterns on the body. Shape and color varies depending on the plant host fed upon. Females expand in size producing several hundred eggs in May and June. Eggs are laid underneath the female covering. After eggs are laid, the female body desiccates, becomes brittle, and turns brown (Figure 72). Eggs hatch and nymphs (crawlers) emerge from beneath the female covering in June and July, migrate to leaves and initiate feeding. Crawlers feed during the growing season, and then in late summer before leaves fall, second-instar nymphs, which are ¼ inch long and yellow-brown in color return to twigs, and overwinter. There is usually one generation per year.

Mites

Twospotted spider mite (*Tetranychus urticae*) adults are about 1⁄16 inch long, oval-shaped, and vary from green-yellow to red-orange, and have two dark spots on both sides of the abdomen (Figure 73). The larvae and nymphs are pale-yellow to yellow-green. Twospotted spider mite feeds on the underside of leaves. Damaged leaves have small white to yellow speckles (Figure 74). This is typically referred to as "stippling." Leaves heavily infested with spider mites may appear yellow to bronze, turn brown, desiccate, and fall off. Webbing may be present on the underside of leaves and plant stems when spider mite populations are excessive. Multiple applications of a contact pesticide (with miticidal activity) may be required throughout the season. In addition, thorough coverage of all plant parts is essential. A forceful water

spray removes all life stages (eggs, larvae, nymphs, and adults) of this mite.

Spruce spider mite (*Oligonychus ununguis*) adults are oval-shaped and approximately ⅙₀ inch long. They may be black, tan, or red, whereas nymphs vary in color from light gray to green. Spruce spider mite adults and nymphs feed primarily on conifers including arborvitae, Douglas fir, hemlock, juniper, and spruce, causing stippling and/or bleaching of affected needles or foliage. Spruce spider mite overwinters in the egg stage. A forceful water spray removes all life stages (eggs, larvae, nymphs, and adults) of this mite. Miticides may be applied; however, thorough coverage of all plant parts is important. A dormant oil spray applied in winter may be effective in killing overwintering eggs on the bark and needles.

Wood-boring insects

Wood-boring insects typically attack stressed trees and shrubs. Females lay eggs on the bark and the eggs hatch into larvae that tunnel into plants and feed within the vascular tissues such as the cambium, phloem, or sapwood (xylem). Borer activity disrupts the flow of water and nutrients in plants and can be damaging or fatal. A variety of beetle and caterpillar borers attack stressed plants. It is important to note that beetle borers (e.g., flat-headed borers) pack their tunneled galleries with sawdust-like frass whereas caterpillar borers (e.g., clear-wing) expel sawdust from cracks in the bark that accumulate at the base of infested plants. Systemic insecticides may be applied preventatively as either a soil drench or directly injected into the tree or shrub. The key is to avoid plant stress by implementing appropriate cultural practices such as watering, fertility, pruning, and mulching.

Beetles

Cottonwood borer (*Plectrodera scalator*) adults are longhorned beetles that are 1 to 1¼ inches long, and have a shiny black and white body with checkered markings (Figure 75). The antennae are similar in length to the body and are solid black. Cottonwood borer attacks cottonwood, poplar, and willow. Larvae are located inside infested trees (Figure 76). Adults can often be seen tunneling into the tree at the soil line. The life cycle requires 2 years to complete.

Smaller European elm bark beetle (*Scolytus multistriatus*) adults are ⅛ inch long and brown to black. A noticeable spine is present on the underside of the abdomen and the wing covers are rounded. Larvae, which are whitish, are located in the inner bark within feeding galleries. This beetle is one of the primary vectors of Dutch elm disease (*Ophiostoma* spp.). European elm bark beetle attacks American, Siberian, and Chinese elms.

Pine sawyer beetle (*Monochamus* spp.) adults of this longhorned beetle are approximately ½ to ¾ inch long with the extended antennae longer than the body. Adults are mottled gray and brown (Figure 77). Larvae are cream-white and 1⅓ to 2 inches in length when full-grown. They are located inside infested trees feeding on the inner bark, cambium, and outer sapwood creating surface galleries that are filled with frass. These beetles are the primary vector of pine wilt disease, described in the disease section.

Walnut twig beetle (*Pityophthorus juglandis*) adults are approximately 1⁄16 inch long, red-brown in color, and about three times as long as wide (Figure 78). Adults possess four to six concentric ridges on the upper surface of the pronotum, which is the shieldlike covering behind and over the head. The larval stage, which is located inside infested trees feeding within the phloem, is white and C-shaped. The walnut twig beetle may be a significant threat because it vectors the fungal disease thousand cankers (*Geosmithia morbida*), which can kill established black walnut trees. It should be noted, however, that as of publication of this guide, neither the walnut twig beetle nor the thousand cankers fungus has been reported in Kansas although there is the potential for introduction into the state. In states where the beetle has been reported, adults have been detected from April through August.

Emerald ash borer (*Agrilus planipennis*) adults are approximately ½ inch long, metallic-green, and shaped like a bullet (Figure 79). The emerald ash borer leaves ⅛ inch wide, D-shaped holes in the bark (Figure 80). The larvae, which are located just beneath the bark, are tapeworm-like with bell-shaped segments (Figure 81). There is a distinct protrusion (cerci) on the end of the abdomen of mature larvae. Emerald ash borer attacks green, white, blue, and black ash trees. As of 2013, the emerald ash borer has been detected in only a few sites in northeast Kansas.

Asian longhorned beetle (*Anoplophora glabripennis*) has not yet been detected in Kansas but is an important insect to be aware of due to its potential for damage. Adults are 1 to 1½ inches long from the head to the end of the abdomen, and shiny black with white spots on the abdomen (Figure 82). The antennae, which contain alternating white and black bands, are just as long as the body of females and twice the body length of males.

These bands can help distinguish the Asian longhorned beetle from the cottonwood borer, which has solid black antennae. Larvae are stout, round, legless, and white to pale-yellow. Mature larvae are 1½ to 2 inches long. Asian longhorned beetle attacks maple, elm, birch, willow, and poplar.

Caterpillars

Lilac/ash borer (*Podosesia syringae*) adults, which are typically active in mid to late April, are brown, clear-wing moths with a 1¼-inch wingspan (Figure 83). Females lay eggs on ash trees, which hatch into cream-colored larvae that are about 1½ inches long when full-grown, with brown heads (Figure 84). Larvae cause plant injury by creating tunnels and feeding within the bark. Larvae may bore farther into the wood and feed within the sapwood and heartwood. Lilac/ash borer typically feeds near the base of plant stems creating swollen areas or cracks at the base of plants and where major branches attach to the trunk. Evidence of larval feeding is the presence of light-colored sawdust below infested areas. Pupal cases may be visible protruding from trees (Figure 85). It is important to maintain plant health through proper watering, fertilization, pruning, and mulching. A contact insecticide may be applied to the bark in early spring to kill adults that emerge from trees and larvae that hatch from eggs.

Plant galls

Many trees and shrubs are subject to attack by gall-forming organisms. Insects, mites, nematodes, bacteria, fungi, and viruses may cause galls. Gall-forming insects and mites include beetles, wasps, moths, midges, sawflies, thrips, scales, adelgids, aphids, psyllids, twig borers, and eriophyid mites. The primary trees and shrubs susceptible to gall-forming insects in Kansas are oak, poplar/cottonwood, and willow. Oaks, in particular, are susceptible to a wide variety of gall-forming insects.

A gall is an abnormal plant swelling caused by a gall-forming insect (or mite), which lives part of its life in the gall, feeding inside the gall on the surrounding content of plant cells. These plant cells are abundant in carbohydrates, protein, and fats. As an insect feeds, it injects growth-reducing chemicals causing plant cells to abandon their normal growth pattern. This gives rise to enlarged cells that divide until an abundance of reorganized tissue envelops the insect. Galls may occur on any plant part including roots, stems (Figure 86), leaves (Figure 87), petioles, fruits, seeds, and terminal shoots. Galls may be used to identify the insects based on shape and the plant species attacked. Galls provide protection from environmental conditions (e.g., temperature extremes, rainfall, and sunlight) and natural enemies (e.g., parasitoids and predators).

Gall abundance depends on the availability of susceptible trees and shrubs. Many galls, in general, are formed on rapidly growing shoots or young trees. In some cases, tree growth rate may determine susceptibility, as faster-growing trees tend to be more susceptible to gall-forming insects than slower-growing trees. This may be due to the number of active growing points for colonization as faster-growing trees have more buds available.

Galls, in general, are not considered a problem as they cause minimal, if any, reduction in plant vigor, and do not kill the plant. Mostly, galls are unsightly and may detract from the appearance of the plant. There is little that can be done to alleviate problems with galls other than using plants that are not susceptible to gall-forming insects. The best way to manage galls is to prune them out, without destroying the aesthetic appearance of the plant. In most cases, especially for gall-forming wasps, pruning must be performed before adults emerge in early spring. This practice may not be feasible for trees heavily infested with galls. The use of pesticides is typically not effective in regulating gall-making insect populations because the insects are well protected. It may be difficult to time applications of contact insecticides with adult emergence.

General pest management and plant health strategies for trees and shrubs

Appropriate cultural practices can promote overall tree and shrub health and help prevent disease epidemics and pest outbreaks.

Use the right plant in the right place. Plants that are not adapted to a site's microclimate, soils, or other site factors are more susceptible to stress as well as diseases and insects. Conduct a thorough site evaluation before selecting plant materials, considering sunlight exposure, slope, soil type, soil pH, drainage, and other characteristics.

Purchase healthy plant material. Plant pathogens and insects may be introduced on contaminated plants or infested soil. Carefully inspect plants for any problems before purchasing and installing them at a site.

Provide proper irrigation. Too much or too little water can cause stress and make trees and shrubs more prone to certain diseases and insects. Frequent overhead irrigation from sprinklers leads to long periods of leaf wetness, which can promote many diseases. Soaker hoses or drip irrigation are less conducive to foliar diseases. Avoid completely saturating the root zone to prevent root health problems and root rot diseases. The soil should be moist but not overly wet. Waterlogged soils can lead to root damage, root diseases, and plant decline.

Provide proper fertility. Similar to water, too much or too little fertilizer can predispose trees and shrubs to diseases and insects. Determine the appropriate fertilizer requirements, including considerations associated with the age of the tree or shrub. Submitting soil for a nutrient analysis may help identify particular fertility practices to implement.

Plant resistant cultivars when available. For some diseases, there are plant cultivars (varieties) that have natural resistance. These cultivars may still develop a low level of disease, but it will be much reduced compared to susceptible cultivars.

Remove and destroy infested plant refuse. Many plant pathogens survive on dead plant material. Removing plant debris reduces the amount of inoculum (pathogen spore and other survival and dispersal structures) for infection the following season.

Prune out infected branches. For some diseases, pruning out the affected plant parts can help reduce disease spread. In some cases, such as fire blight, pruning tools should be disinfected between cuts. Pruned branches should be removed from the site and, in some cases, destroyed (chipped, burned, or buried).

Control weeds. Weeds and grass compete with young or recently transplanted trees for nutrients and water. Keep the soil beneath the tree crown free of weeds and grass. Mulching to a 2 to 4 inch depth beneath the crown helps control weeds and benefit recently transplanted trees and shrubs. Avoid placing mulch directly in contact with the trunk.

Use chemicals judiciously. Most tree and shrub diseases and insect pest infestations do not require any pesticides. In some cases, pesticides may be beneficial, such as sites with chronic, destructive problems that reduce plant health year after year. Accurate identification of the problem, proper timing, and application method are critical for control. See the section below for more information on chemical use.

Pesticide use for disease, insect, and mite management in trees and shrubs

Most tree and shrub diseases, insect pests, and mite pests do not require any pesticide applications. Many diseases, insects, and mites require no management at all because they are unlikely to reach damaging thresholds. If management is initiated, the cultural practices described throughout this guide should be the first step. For example, consider planting a resistant variety or a nonhost. If cultural practices do not reduce disease, insect, or mite population to nondamaging levels, in some situations pesticides may be warranted. Fungicides, bactericides, insecticides, and miticides control fungi, bacteria, insects, and mites, respectively. When pesticides are used, they should be applied carefully following all instructions on the pesticide label regarding allowed uses, rates, timing, application equipment, personal protective equipment, storage, and other factors. Accurate diagnosis

and thorough knowledge of the biology and life cycle of the pest or disease is essential in order to select an appropriate pesticide and maximize its efficacy while reducing nontarget effects.

Pesticides vary in their physical mode of action, or their ability to move in or on plant tissue. This can be important when selecting a product. Contact materials do not penetrate the plant. They remain on the plant surface with limited redistribution. Therefore, thorough coverage is essential — plant parts that are not covered will not be protected, and new tissues that emerge after application will not be protected.

Some pesticides are systemic, meaning they penetrate the plant tissue and are translocated within the plant. Locally systemic pesticides penetrate the plant only at the site of application, with little translocation within the plant. Some local systemics have translaminar properties, meaning they move from one leaf surface to another, which can be useful when it is difficult to achieve thorough coverage. Other materials, called acropetal penetrants, move upward in the plant. A small number of materials can move both up (acropetal movement) and down (basipetal movement) in the plant. Keep this in mind particularly with root diseases as these materials may need to be watered or drenched into the root zone to reach the area where the pathogen is active. Even with systemic materials, thorough coverage will increase efficacy.

Pesticides for disease management

With respect to disease management, there are several other factors to consider regarding the use of pesticides. Contact materials are effective only when used in a preventative manner. They must be applied before the pathogen arrives and penetrates (colonizes) the plant tissue. In contrast, systemic materials have a certain level of postinfection activity, meaning sometimes they can reduce pathogen growth even after the pathogen has begun to colonize the plant. However, even systemic products are most effective when used preventatively or early in the disease development. The product labels will provide information on optimal timing of application.

There are several classes of systemic fungicides, each with a unique mode of action. That is, the different classes affect a specific physiological process in the cells of the target fungus, such as certain proteins involved in cell membrane production, cell division, or energy production (respiration). Contact materials tend to have multiple modes of action, meaning they affect numerous physiological processes in the cells of the target fungi. Details on these modes of action are beyond the scope of this publication, but other resources can be used to learn more about these concepts.

Pesticides for insect and mite management

Successful management of insect and mite pests with pesticides (in this case, insecticides and miticides) involves implementation of appropriate procedures including proper coverage, timing of application, and frequency of application. There are two primary groups of pesticides associated with regulation of insect and mite pest populations: contact and systemic. Contact pesticides are materials that kill an insect or mite pest by direct contact or when an insect or mite pest walks or crawls over a treated surface. The active ingredient enters the feet and moves to the site of action. Systemic pesticides, which are primarily applied as a drench or granule to the soil, involve the active ingredient being taken up by the roots and then translocated or distributed throughout the plant into locations (e.g., leaves) where insects feed. Another group of pesticides are stomach poisons in which the insect pest feeds on a treated surface and ingests the insecticide, which is then absorbed through the stomach lining. It is always recommended to read the pesticide label before making any application.

There are a number of pesticides that may be used to suppress or regulate insect and mite populations with distinct modes of action. The mode of action is how a pesticide affects the metabolic or physiological processes in an insect or mite pest. Many pesticides have site-specific or narrow modes of action that negatively influence some component of the central nervous system or disrupt the production of energy of the target pest. Other pesticides, including insecticidal soaps and horticultural oils, have broad modes of activity and either desiccate or smother the target pest.

Diagnosing tree and shrub problems

If a tree or shrub problem arises, it is critical to make an accurate diagnosis before taking action. An incorrect diagnosis may lead to incorrect management practices including inappropriate use of pesticides.

Some tree and shrub problems are relatively easy to identify; others, such as root diseases and vascular wilts, are much more difficult to diagnose without considerable experience. It is important to have as much information as possible about the plant and site before making a diagnosis. Some factors to consider include:

What is the species of the affected plant? Correct identification of the plant species is critical. Many diseases and pests are specific to certain plant hosts, so this information makes it possible to focus on problems most common on that species. It is also helpful to determine the cultivar/variety. If multiple species are affected, an abiotic problem may be more likely.

What is the overall condition of the site? Make observations on soil type, potential drainage problems, sun/shade exposure, irrigation, recent construction, and other site factors.

What has been the recent weather? Drought, excessive moisture, heat, cold, and wind can all affect tree and shrub health. Wet weather triggers some diseases, such as leaf spots, whereas hot, dry weather causes other problems.

What cultural practices have been conducted at the site? Determine the irrigation, fertilization, pruning, and other tree/shrub management practices that have been implemented. These factors play an important role in disease, insect, and mite pressure as well as abiotic stresses.

What is the distribution of the problem? Determine if the problem is uniform, clumped, or random. Determine if there are any physical structures or soil differences that may contribute to the problem. In general, diseases, insects, and mites tend to cause clumped and random patterns, whereas abiotic factors tend to cause uniform patterns of damage.

What part of the plant is affected? Often, diagnosis is based entirely on leaf symptoms when the primary symptom(s) and actual cause of the problem may be associated with the roots or trunk. Check the entire plant for any evidence of injury. Specifically, look for leaf spots, wilting, rotting roots, cankers, mechanical wounds, etc.

Once detailed information on the cultural conditions, pattern of the problem, and specific symptoms have been obtained, a diagnosis may be attempted. Compare the information gathered with photographs and descriptions of problems in extension bulletins, books, and websites. If the diagnosis is still uncertain, get assistance from your local K-State Research and Extension office. You may also contact the following laboratories at Kansas State University:

K-State Plant Disease Diagnostic Lab
4032 Throckmorton PSC
Manhattan, KS 66506
Phone: (785) 532-5810
Fax: (785) 532 5692
email: clinic@ksu.edu

K-State Insect Diagnostic Laboratory
123 West Waters Hall
Manhattan, KS 66506
Phone: (785) 532-4739
email: gotbugs@ksu.edu

K-State Agronomy Soil Testing Lab
2308 Throckmorton Plant Sciences Center
Manhattan, KS 66506
Phone: (785) 532-7897
Fax: (785) 532-7412

K-State Herbarium (Plant/Weed Identification)
Herbarium Division of Biology — Ackert Hall
Kansas State University
Manhattan, KS 66506
Phone: (785) 532-6619
email: herbarium@ksu.edu

Supplemental resources

Coulson, R. N., & Witter, J. A. (1984) *Forest Entomology: Ecology and Management*. John Wiley & Sons, Inc., New York, NY. 669 pages.

Cranshaw, W. (2004) *Garden Insects of North America*. Princeton University Press, Princeton, NJ. 656 pages.

Dirr, M. A. (2009) *Manual of Woody Landscape Plants: Their Identification, Ornamental Characteristics, Culture, Propagation, and Uses*. Sixth Edition. Stipes Publishing LLC, Champaign IL. 1,325 pages.

Hartman, JR, Pirone, TP, & Sall, MA. (2000) *Pirone's Tree Maintenance*. Seventh Edition. Oxford University Press. 545 pages.

Horst, R. K. (2008) *Westcott's Plant Disease Handbook*, 7th edition. Springer. 1,317 pages.

Horst, R. K. & Cloyd, R. A. (2007) *Compendium of Rose Diseases and Pests*. Second Edition. APS Press. St. Paul, MN. 96 pages.

Integrated Pest Management of Midwest Landscapes. (2004) Cooperative Project of NCR-193, North Central Committee on Landscape IPM, Minnesota Agricultural Experiment Station SB-07645. 315 pages.

Johnson, W. T., & H. H. Lyon. (1988) *Insects That Feed on Trees and Shrubs*. Cornell University Press, Ithaca, NY. 556 pages.

Luley, C. J. (2005) *Wood Decay Fungi Common to Urban Living Trees in the Northeast and Central United States*. Urban Forestry LLC.

Plant Health Care for Woody Ornamentals. (1997) International Society of Arboriculture, Savoy, IL, and Cooperative Extension Service; College of Agricultural, Consumer and Environmental Sciences, University of Illinois at Urbana-Champaign, IL. 223 pages.

Sinclair, W. A. & Lyon, H. H. (2005) *Diseases of Trees and Shrubs*. Second Edition. Cornell University Press. 660pages.

Common diseases, insect pests, and environmental stress problems of trees and shrubs in Kansas

Tips on using this table: This table is arranged by host species (tree or shrub species) in alphabetical order by the common name. The information is meant to be a quick guide, or starting point for determining potential causes of tree and shrub problems, primarily in the ***landscape***. Other resources are available for more detailed information for nurseries or other production facilities - contact the KSU Plant Disease Diagnostic Lab for information.

Host	***Diseases and Environmental Stresses***	***Symptoms/Identification***	***Comments***
Almond flowering/ornamental – see Cherry			
Amelanchier – see Serviceberry			
Arborvitae *Thuja occidentalis* and *Thuja orientalis*	Fall needle drop	Interior needles turn brown and drop in fall, especially in drought years.	Provide adequate water.
	Kabatina tip blight *Kabatina juniperi*	Upper 2-6 inches of branch tips turn red or yellow, usually in late winter/early spring (Figures 98 – 99). Affected tips dry out and drop off in late spring/early summer. Primarily a cosmetic problem. Occasional.	Space plants appropriately to allow airflow; avoid wounding plants; avoid irrigation that wets the foliage; prune out and remove/ destroy affected branch tips.
	Seiridium canker *Seiridium unicorne*	Branches and stems develop long, flat cankers, sometimes with bleeding. Entire trees, sections of trees, or individual branches may turn dull green then brown in late spring or early summer. Most severe on exposed sites.	Winter injury and other abiotic issues make trees more susceptible to the canker. See general discussion of cankers on Page 8 and winter injury on Page 2. Prune out cankered branches and destroy them. Provide adequate water.
	Winter injury	Branch dieback.	See general discussion of winter injury on Page 2. Can predispose plants to Seiridium canker (see above).
	Bagworm *Thyridopteryx ephemeraeformis* (see Page 11)	Caterpillars create small bags or cases covered with material from host plant. Feeding causes browning of leaf tips. Young caterpillars are ⅛ to ¼ inch long whereas the mature caterpillar bags are 1 to 2 inches long (Figures 52 – 53).	Can cause substantial damage if not dealt with. Contact or stomach poison insecticides may be used to deal with extensive infestations. Removing female bags by hand in the winter may be effective in reducing caterpillar populations the following season.

Host	Diseases and Environmental Stresses	Symptoms/Identification	Comments
Arborvitae, cont.	Spruce spider mite *Oligonychus ununguis* (see Page 14)	Feeding by mites causes foliage to change color, turning mottled in appearance, and then yellow and eventually bronze. Damaged needles may fall off prematurely. Heavy infestations may cause branch dieback.	A forceful water spray will remove all life stages (eggs, larvae, nymphs, and adults). Miticides may be applied; however, thorough coverage of all plant parts is important. A dormant oil spray applied in winter may be effective in killing overwintering eggs located on the bark and needles.
Ash *Fraxinus* sp.	Anthracnose *Discula fraxinea* also called *Gnomoniella fraxini*	Irregular, brown blotches or spots develop on leaves, commonly associated with leaf veins or margins. Premature leaf shedding. Twig and shoot blight phases may occur with minor twig shedding. Disease more prevalent in late spring/early summer during wet weather.	Rarely damaging, primarily cosmetic, no management needed. See general discussion of anthracnose diseases on Page 6 for more information.
	Ash leaf spot *Mycosphaerella fraxinicola*	Brown leaf spots, usually ¼ to ½ inch in diameter, with yellow margins develop in late summer. Leaf spots coalesce and severely affected leaves drop prematurely. In wet years, disease may appear in early- to mid-summer (Figure 11).	Rarely damaging, primarily cosmetic, no management needed. See general discussion of leaf spots on Page 6 for more information. If a series of wet years occurs, with early symptoms and repeated early defoliation, tree health may be affected. Rake up and destroy affected leaves.
	Ash rust *Puccinia sparganioides*	Bright orange powdery cups form on leaves. Leaves and petioles become twisted, distorted, or swollen (Figures 19 – 20).	Rarely damaging, primarily cosmetic, no management necessary.
	Environmental scorch	Leaf margins and/or entire leaves turn brown and dry (scorched) during dry, windy conditions.	Provide adequate water. Use mulches to help retain soil moisture. See general discussion of environmental scorch on Page 2.

Host	Diseases and Environmental Stresses	Symptoms/Identification	Comments
Ash, cont.	Heart rot and decay *Perenniporia fraxinophila* and others	Symptoms of decay may not be visible until extensive structural damage to the tree has resulted. Bracket-shaped conks (fruiting bodies) indicate the presence of decay (Figure 88).	Fungus enters through wounds and branch stubs, therefore prevent wounds to trees and prune properly. There is no control once the fungus has colonized the wood. Trees with indications of decay should be evaluated by a tree-care professional. Trees that are a structural risk should be removed by a certified arborist. See the general discussion of wood decay on Page 9 for more information.
	Mycosphaerella leaf spot – see Ash leaf spot		
	Powdery mildew	White, powdery fungal growth develops on leaf surfaces.	Rarely damaging, primarily cosmetic, no management necessary. Improving airflow may reduce severity. See general discussion of powdery mildew on Page 7.
	Ash/lilac borer *Podosesia syringae* (see Page 15)	Larvae cause plant injury by tunneling and feeding within trees, which cause isolated branch dieback. Pupal cases may be noticed protruding from infested trees. Adults are clear-wing moths. Light-colored sawdust may also be present at the base of infested trees (Figures 83 – 85).	Maintain plant health through proper watering, fertilization, pruning, and mulching. A contact insecticide may be applied to the bark in early spring to kill adults that emerge from trees and larvae that hatch from eggs laid by females.
Azalea – see Rhododendron			
Bald cypress *Taxodium distichum*	Iron chlorosis	Yellowing of foliage.	Avoid planting susceptible species in high pH soils. In severe cases provide iron with injections. See general discussion of iron chlorosis on Page 4.
Barberry *Berberis*	Environmental scorch	Leaf margins and/or entire leaves turn brown and dry (scorched) during dry, windy conditions.	Provide adequate water. Use mulches to help retain soil moisture. See general discussion of environmental scorch on Page 2.

Host	Diseases and Environmental Stresses	Symptoms/Identification	Comments
Barberry, cont.	Powdery mildew	White, powdery fungal colonies develop on leaf surfaces. More common on golden barberry, rare on red barberry. Leaf shedding can occur.	Rarely damaging, primarily cosmetic, no management necessary. See general discussion of powdery mildew on Page 7.
	Root decline (wet feet)	Dieback, branch decline, dark colored roots.	Plant into well-drained soils. See comments on wet soils on Page 3.
	Verticillium wilt *Verticillium dahliae*	Wilting, yellowing, decline, dieback. Vascular discoloration (brown streaking) may be visible when viewing cross-section of cut branches or when bark is removed.	Maintain overall plant health with appropriate watering, fertilization, etc. Do not replant a susceptible species into a site with history of Verticillium wilt. See general discussion of Verticillium wilt on Page 8.
Basswood – see Linden			
Birch *Betula* spp. **White birch** *Betula papyrifera* **River birch** *Betula nigra*	Environmental scorch	Leaf margins and/or entire leaves turn brown and dry (scorched) during dry, windy conditions. White birch is not adapted to the Kansas climate and is prone to scorch and other environmental stresses.	Provide adequate water. Use mulches to help retain soil moisture. See general discussion of environmental scorch on Page 2.
	Leaf spot various fungi	Small brown leaf spots. Leaf yellowing and shedding. Primarily occurs on river birch during wet summers.	Rarely damaging, primarily cosmetic, no management needed. See general discussion of leaf spots on Page 6 for more information.
	Bronze birch borer *Agrilus anxius*	Branch swelling and bleeding, followed by a dieback and decline. Infested trees typically have ridged or swollen bark where larvae have fed. Look for D-shaped holes in the bark. Primarily occurs on white birch.	Maintain plant health through proper watering, fertilization, pruning, and mulching. A contact insecticide may be applied to the bark in spring to kill adults that emerge from trees and larvae that hatch from eggs. A systemic insecticide may also be applied to the soil early in the spring as plants are leafing-out.
	Fall webworm *Hyphantria cunea* (see Page 11)	Create large nests or webbing in tree branches. Caterpillars, which are yellow-green to brown in color with black spots, remain in the nests feeding (Figures 56 – 58).	Prune out localized nests or webbing and dispose of immediately. Use a rake to disrupt the nest, which will allow birds to feed on the caterpillars.

Host	Diseases and Environmental Stresses	Symptoms/Identification	Comments
Black locust *Robinia pseudoacacia*	Heart rot *Phellinus robiniae*	The fungus causes a white rot of the heartwood leading to spongy yellow tissue. Large, brown to black bracket-shaped conks form on the bark. The disease is often associated with locust borer injury. Common in old trees.	Fungus enters through wounds and branch stubs, therefore prevent wounds to trees and prune properly. There is no control once the fungus has colonized the wood. Trees with indications of decay should be evaluated by a tree-care professional. Trees that are a structural risk should be removed by a certified arborist. See general discussion of wood decay on Page 9.
Boxwood *Buxus*	Leaf spots various fungi	Round, brown spots (lesions) develop on foliage.	Rarely damaging, primarily cosmetic, no management needed. See general discussion of leaf spots on Page 6 for more information.
	Boxwood blight *Cylindrocladium buxicola,* also called *Cylindrocladium pseudonaviculatum*	Circular, brown leaf spots. Unlike general leaf spots, boxwood blight causes rapid defoliation as well as black lesions on twigs and stems. Favored by cool wet weather. Not known to occur in Kansas but could become introduced on infected nursery stock.	Inspect all nursery stock. Do not plant suspect materials. Report potential cases of boxwood blight to KSU Plant Diagnostic Laboratory.
	Canker various fungi	Small, sunken cankers cause branch dieback and death of the plant. Some canker fungi produce small orange-pink fruiting structures on affected branch tissue.	Keep plants in vigorous condition by proper management. Prune infected branches back to healthy wood in the spring. See general discussion of cankers on Page 8.
Catalpa *Catalpa* spp.	Verticillium wilt *Verticillium dahliae*	Wilting, yellowing, decline, dieback. Vascular discoloration (brown streaking) may be visible when viewing cross-section of cut branches or when bark is removed.	Maintain overall plant health with appropriate watering, fertilization, etc. Do not replant a susceptible species into a site with history of Verticillium wilt. See general discussion of Verticillium wilt on Page 8.
	Iron chlorosis	Yellowing of leaf tissue between veins; veins remain green.	Avoid planting susceptible species in high pH soils. In severe cases provide iron with injections. See general discussion of iron chlorosis on Page 4.

Host	Diseases and Environmental Stresses	Symptoms/Identification	Comments
Catalpa, cont.	Leaf spots various fungi	Discrete spots or irregular white blotches develop on leaves. Usually late in season.	Rarely damaging, primarily cosmetic, no management needed. See general discussion of leaf spots on Page 6 for more information.
	Powdery mildew	White, powdery fungal growth develops on leaf surfaces.	Rarely damaging, primarily cosmetic, no management necessary. Improving airflow may reduce severity. See general discussion of powdery mildew on Page 7.
Cedar – see Juniper			
Cherry, peach, almond, plum **Flowering, ornamental** *Prunus* For trees grown for fruit production, other references are available.	Canker *Cytospora*	Bark may be sunken, cracked, or discolored. Fungal fruiting structures may be present. Tissue under the affected bark is dead. Tree may produce abundant gummy resin.	Prune out affected limbs and remove or destroy the wood. Maintain overall plant health with proper pruning, fertilization and irrigation. See general discussion of cankers on Page 8.
	Bacterial leaf spot *Xanthomonas arboricola* pv. *pruni*	Small, dark leaf spots develop, eventually turning dry and falling out to produce a tattered, shothole pattern. Favored by wet conditions. Fruit spotting also may occur.	Rarely damaging, primarily cosmetic, no management needed. See general discussion of leaf spots on Page 6 for more information.
	Black knot *Apiosporina morbosa*, also called *Dibotryon morbosum*	Corky, swollen growths develop on twigs, branches, or trunks. Young knots are greenish and soft, old knots are hard and blackened (Figure 89). Affected limbs are girdled, and tree can decline/die.	Inspect trees each winter and prune out symptomatic branches 6-8 inches below the visible knot, and remove and discard or burn the wood.
	Brown rot *Monilinia fructicola*	The fungus causes blighted shoots and flowers. Fruit rot and develop a brown, fuzzy fungal growth then dry into "mummies."	Prune and destroy infected twigs. Remove mummy fruit from tree and the ground below tree.
	Cherry leaf spot *Blumeriella jaapii*	Small, purple-brown spots develop on leaves. Leaves may turn yellow and fall prematurely. Little impact on landscape flowering trees.	Rarely damaging, primarily cosmetic, no management needed. See general discussion of leaf spots on Page 6 for more information. If infection is severe, rake up and remove fallen infected leaves.

Host	Diseases and Environmental Stresses	Symptoms/Identification	Comments
Cherry, peach, almond, plum, cont.	Crown gall *Agrobacterium tumefaciens*	Large woody galls develop, usually on root collar or roots. Galls reduce plant vigor and eventually can kill plant. Causal bacterium persists long term in soil at the site (Figure 38).	Avoid planting infected materials. Inspect before purchasing/planting. Remove and destroy entire infected plants. Do not simply prune out galls. Do not replant with a susceptible host. See further details in general discussion of crown gall on Page 8.
	Peach leaf curl *Taphrina deformans*	Leaves are curled, puckered, thickened, and distorted with a greenish or reddish color (Figure 90). Infected leaves fall off the tree.	If defoliation is severe, maintain overall tree vigor with appropriate irrigation and fertilizer. Fungicides prior to spring bud swell can reduce disease.
	Plum pocket *Taphrina communis*	Fruits become enlarged, hollow, and distorted.	Little damage to tree, no management needed.
	Eastern tent caterpillar *Malacosoma americanum* (see Page 11)	Create nests (tents) in the crotches of twigs. Caterpillars feed on newly emerging leaves in spring (Figures 54 – 55).	Physically remove or disrupt the nest early in the spring. This will avoid having to use a contact or stomach poison insecticide.
Cotoneaster *Cotoneaster*	Environmental scorch	Leaf margins and/or entire leaves turn brown and dry (scorched) during dry, windy conditions.	Provide adequate water. Use mulches to help retain soil moisture. See general discussion of environmental scorch on Page 2.
	Fire blight *Erwinia amylovora*	Sudden browning and wilting of branch spurs (Figure 91) or new shoot growth. Tips of blighted shoots curl, giving appearance of a "shepherd's crook" (Figure 92). Inner bark tissue turns water soaked with red-to-black discoloration. Cankers form on affected branches. Favored by wet spring weather.	Prune out affected branches at least 12 inches below visible damage. Sanitize tools between cuts. See further discussion of fire blight under crabapple.
	Leaf spots various fungi	Round, brown spots (lesions) develop on foliage.	Rarely damaging, primarily cosmetic, no management needed. See general discussion of leaf spots on Page 6 for more information.

Host	Diseases and Environmental Stresses	Symptoms/Identification	Comments
Cotoneaster, cont.	Powdery mildew	White, powdery fungal growth develops on leaf surfaces.	Rarely damaging, primarily cosmetic, no management necessary. Improving airflow may reduce severity. See general discussion of powdery mildew on Page 7.
	Lace bug *Corythucha cydoniae* (see Page 12)	Damage appears as light-yellow mottling or stippling on the upper leaf surface. Black eggs and nymphs, and lacy-appearing adults may be present on leaf undersides (Figures 64 – 66).	In general, lace bugs will not severely damage plants although extensive populations may reduce aesthetic appearance. Contact insecticides may be used; however, thorough coverage of leaf undersides is important.
Cottonwood – see Poplar			
Crabapple *Malus* For apple trees grown for fruit production, other references are available. Contact your local extension office.	Cankers *Botryosphaeria* and other fungi	Cankers develop on trees damaged or weakened from sunscald, drought, insect injury, or chronic leaf spot diseases with repeat defoliation (see rust and scab). Sunken or discolored bark tissue and branch dieback are common symptoms.	Prune out affected branches. Maintain overall plant health with proper pruning, fertilization and irrigation. See general discussion of cankers on Page 8.
	Fireblight *Erwinia amylovora*	Sudden browning and wilting of branch spurs (Figure 91) or new shoot growth. Tips of blighted shoots curl, giving appearance of a "shepherd's crook" (Figure 92). Inner bark tissue turns water soaked with red-to-black discoloration. Cankers form on affected branches. Favored by wet spring weather.	Prune out affected branches, in winter if possible, at least 12 inches below visible damage. Disinfect pruning tools in 10 percent solution of household bleach or 70 percent alcohol between each cut. Oil pruning tools afterwards to prevent corrosion. Avoid over-fertilization. Avoid pruning in spring/summer especially in wet weather.
	Powdery mildew	White, powdery fungal growth develops on leaf surfaces. Leaves may be crinkled or deformed.	Rarely damaging, primarily cosmetic, no management necessary. Improving airflow may reduce severity. See general discussion of powdery mildew on Page 7.

Host	Diseases and Environmental Stresses	Symptoms/Identification	Comments
Crabapple, cont.	Rust – cedar apple rust *Gymnosporangium juniperi-virginianae*	Most common rust disease on crabapple. Yellow-orange spots develop on leaves (Figure 23). Cup-like structures develop on leaf undersides. Defoliation can occur. Occasional raised orange spotting on fruit.	Plant resistant varieties. Preventative fungicides may be useful in cases with chronic, severe defoliation. See general discussion of rusts on Page 7.
	Scab *Venturia inaequalis*	Olive-green spots develop on upper and lower leaf surfaces in the spring (Figure 12). Fruit lesions are rough or scaly, and appear dark green when wet. Numerous leaf infections will cause premature defoliation and will result in a loss of tree vigor.	The best means of control is the use of resistant cultivars. The disease may be partially controlled on susceptible varieties by removing leaf debris in the fall. In cases of chronic, severe infection, spring fungicides may be beneficial to tree health.
	Wood decay *Xylaria*, others	Tree may show dieback/decline. Decayed, rotted wood (crumbly, spongy, discolored). Mushrooms or conks may be present. *Xylaria* fruiting structures are finger-shaped, black, charcoal-like projections.	Fungus enters wounds and branch stubs —prevent tree wounds and prune properly. There is no control once the fungus has colonized the wood. Trees with signs of decay should be evaluated by a tree-care professional. Trees that are a structural risk should be removed by a certified arborist. See general discussion of wood decay on Page 9 for more information.
	Eastern tent caterpillar *Malacosoma americanum* (see Page 11)	Create nests (tents) in the crotches of twigs. Caterpillars feed on newly-emerging leaves in spring (Figures 54 – 55).	Physically remove or disrupt the nest early in the spring. This will avoid having to use a contact or stomach poison insecticide.
	Fall webworm *Hyphantria cunea* (see Page 11)	Create large nests or webbing in tree branches. Caterpillars, which are yellow-green to brown in color with black spots, remain in the nests feeding (Figures 56 – 58).	Prune out localized nests or webbing and dispose of immediately. Use a rake to disrupt the nest, which will allow birds to feed on the caterpillars.
	Japanese beetle *Popillia japonica* (see Page 10)	Adults are metallic green in color with coppery-brown wing covers. White tufts of hair are present at the end of the abdomen. Feeding by adults causes leaves to appear lace-like or skeletonized (Figure 48).	Handpicking of adult beetles may be effective for situations associated with small trees and low infestations. However, contact insecticides may be required to prevent substantial damage to plants.

Host	Diseases and Environmental Stresses	Symptoms/Identification	Comments
Dogwood *Cornus*	Leaf spot *Septoria,* others	Small, angular, brown, gray, or purple lesions with whitish center. (Figure 13). Usually appears late in season and does not affect health of plant. Red twig dogwood is most susceptible.	Little damage, and management not necessary. Raking and removing fallen leaves may reduce disease somewhat in following year. See discussion of leaf spots on Page 6.
Douglas fir *Pseudotsuga menziesii*	Environmental scorch	Needles turn brown, starting at tips. Occurs during dry, windy weather in all seasons.	Provide adequate water. See general discussion of environmental scorch and winter desiccation on Page 2.
Elm *Ulmus*	Anthracnose – see black spot		
	Bacterial wetwood several bacterial species	Liquid oozes from wounds and cracks and runs down bark, leaving discolored streaks on branches or trunk (Figure 42).	Rarely damaging, primarily cosmetic, management not necessary. See general discussion of wetwood on Page 9.
	Black spot *Stegophora ulmea* also called elm anthracnose	Symptoms generally appear in mid to late summer. On American elm, small, black irregular lesions or blotches form on the upper surface of the leaves.(Figure 93). On Siberian elm, leaf spots are gray. Heavily infected leaves turn yellow and drop from the tree. Petioles and new twigs can also be infected. Defoliation may be extensive during wet summers.	Rarely damaging, primarily cosmetic, no management needed. See general discussion of anthracnose and leaf spots on Page 6.
	Cankers *Botryodiplodia, Nectria, Dothiorella* and others	Common on Siberian and lacebark elms. Dark, sunken lesions or depressions form on twigs and branches. Branch dieback and overall tree decline may occur.	Maintain overall plant health with proper pruning, fertilization and irrigation. See general discussion of cankers on Page 8. If cankers develop, prune out and remove or destroy affected wood.
	Dutch elm disease *Ophiostoma novo-ulmi* and *Ophiostoma ulmi*	Yellowing, browning, and wilting of leaves, often on scattered branches causing "flagging" (Figure 29). Discoloration (brown streaking) may be visible in vascular tissue when cut branches are viewed in cross section or bark is removed (Figure 30). Entire tree may die in a few weeks or up to a year or more.	Remove and destroy infected trees, destroying root grafts with neighboring elms beforehand. If disease is detected early (less than 5 percent canopy symptoms), pruning affected branches may prevent spread within the tree. Wood should not be saved for firewood. See detailed discussion of Dutch elm disease on Page 7.

Host	Diseases and Environmental Stresses	Symptoms/Identification	Comments
Elm, cont.	Leaf curl *Taphrina ulmi*	Light-green blisters develop on the upper surface of leaves in early spring. Later, the lesions turn brown. Infection is restricted to the period when new leaves are emerging in the spring.	Rarely damaging, primarily cosmetic, no management needed.
	Sooty mold fungi	Black moldy growth on the surface of leaves and succulent stems. The sooty mold fungi are not parasitic to the plant, they are saprophytes living on insect (ex: aphid, scale) honeydew.	Sooty mold does not cause serious injury and control of the fungus is not necessary; however, the presence of sooty mold can be an indication of heavy insect activity.
	Squirrel damage	Squirrels chew bark strips off causing twig and branch dieback. Occurs in occasional years.	No management. See comments on animal damage in general introduction.
	Verticillium wilt *Verticillium dahliae*	Wilting, yellowing, decline, dieback (Figure 31). Vascular discoloration (brown streaking) may be visible when viewing cross-section of cut branches or when bark is removed (Figure 32).	Maintain overall plant health with appropriate watering, fertilization, etc. Do not replant a susceptible species into a site with history of Verticillium wilt. See general discussion of Verticillium wilt on Page 8.
	European elm scale *Gossyparia spuria* (see Page 13)	Adults are long, oval in shape with a brown shell encircled by a white waxy substance. May produce copious amounts of honeydew (sticky liquid) (Figure 70).	Prune out localized infestations of European elm scale. Contact insecticides or horticultural oils may be applied when crawlers are active during the season.
	Elm leaf beetle *Pyrrhalta luteola* (see Page 10)	Feeding by adults causes shot holes between leaf veins whereas the larvae feed on the leaf undersides resulting in skeletonization of leaves. Damaged leaves eventually turn brown and dry up (Figures 46 – 47).	Apply contact insecticides at the first appearance of both adults and larvae, which may be found feeding simultaneously. Thorough coverage of both the upper and under sides of leaves is essential.
Euonymus *Euonymus*	Crown gall *Agrobacterium tumefaciens*	Large woody galls develop, usually on root collar or roots (Figure 38). Galls reduce plant vigor and eventually can kill plant. Causal bacterium persists long term in soil at the site.	Avoid planting infected materials. Inspect before purchasing/planting. Remove and destroy entire infected plants. Do not simply prune out galls. Do not replant with a susceptible host. See further details in general discussion of crown gall on Page 8.

Host	Diseases and Environmental Stresses	Symptoms/Identification	Comments
Euonymus, cont.	Environmental scorch	Leaf margins and/or entire leaves turn brown and dry (scorched) during dry, windy conditions (Figure 1).	Provide adequate water. Use mulches to help retain soil moisture. See general discussion of environmental scorch on Page 2.
	Iron chlorosis	Yellowing of leaf tissue between veins; veins remain green.	Avoid planting susceptible species in high pH soils. In severe cases provide iron with injections. See general discussion of iron chlorosis on Page 4.
	Powdery mildew	White, powdery fungal growth develops on leaf surfaces.	Rarely damaging, primarily cosmetic, no management necessary. Improving airflow may reduce severity. See general discussion of powdery mildew on Page 7.
	Winter injury	Branches die back, sometimes to the ground. In spring new leaves may emerge but wilt rapidly and die due to damage to branches.	See general discussion of winter injury on Page 2.
	Winter desiccation	Browning of leaf margins during dry, windy weather.	Provide adequate water. Use mulches to help retain soil moisture. See general discussion of environmental scorch and winter desiccation on Page 2.
	Euonymus scale *Unaspis euonymi* (see Page 13)	The upper surface of leaves may appear yellow or mottled. The underside of leaves may be covered with both white (male) and brown (female) scales (Figure 71).	Prune out heavily infested branches and dispose of immediately. Apply a contact insecticide or horticultural oil when crawlers are active during the season.
Firethorn – see Pyracantha			
Forsythia *Forsythia*	Crown gall *Agrobacterium tumefaciens*	Large woody galls develop, usually on root collar or roots (Figure 38). Galls reduce plant vigor and eventually can kill plant. Causal bacterium persists long term in soil at the site.	Avoid planting infected materials. Inspect before purchasing/planting. Remove and destroy entire infected plants. Do not simply prune out galls. Do not replant with a susceptible host. See further details in general discussion of crown gall on Page 8.

Host	Diseases and Environmental Stresses	Symptoms/Identification	Comments
Forsythia, cont.	Leaf spots various fungi	Round, brown spots (lesions) develop on foliage.	Rarely damaging, primarily cosmetic, no management needed. See general discussion of leaf spots on Page 6 for more information.
	Phomopsis twig gall Associated with *Phomopsis* fungus, but true causation not well understood	Small (1 to 2 inches in diameter), lumpy, rough, woody galls on aerial branches (Figure 94). Occasionally causes branch dieback.	Rarely damaging. Primarily cosmetic. Maintain overall plant vigor with proper watering, fertilization, etc. Avoid wounding plants. Prune out affected branches during dry weather at least 6 to 8 inches below gall.
	Bagworm *Thyridopteryx ephemeraeformis* (see Page 11)	Caterpillars create small bags or cases covered with material from host plant. Feeding causes browning of leaves. Young caterpillars are ⅛ to ¼ inch long whereas the mature caterpillar bags are 1 to 2 inches long (Figure 52 – 53).	Can cause substantial damage if not dealt with. Contact or stomach poison insecticides may be used to deal with extensive infestations. Removing female bags by hand in the winter may be effective in reducing caterpillar populations the following season.
Goldenrain Tree *Koelreuteria*	Nectria canker *Nectria cinnabarina*	Dieback on one or more branches. Dead branches are light tan and dotted with black to red fruiting structures of the fungus. Infection is associated with winter injury.	Maintain overall plant health with proper pruning, fertilization and irrigation. See general discussion of cankers on Page 8. Remove cankered branches in late winter.
	Verticillium wilt *Verticillium dahliae*	Wilting, yellowing, decline, dieback (Figure 31). Vascular discoloration (brown streaking) may be visible when viewing cross-section of cut branches or when bark is removed (Figure 32).	Maintain overall plant health with appropriate watering, fertilization, etc. Do not replant a susceptible species into a site with history of Verticillium wilt. See general discussion of Verticillium wilt on Page 8.
Hackberry *Celtis occidentalis*	Hackberry decline environmental decline	Pale foliage, thin crown, poor growth, overall tree decline. Thought to be caused by poor site conditions and stressful environmental conditions.	Promote overall tree health with appropriate water, fertilizer, pruning, etc.

Host	Diseases and Environmental Stresses	Symptoms/Identification	Comments
Hackberry, cont.	Root rot *Ganoderma lucidum*, others	The disease causes decline and death of the tree. The fungus causes a white, spongy rot of the roots and root collar. In the advanced stages of Ganoderma root rot, the fungus produces amber to reddish-brown, hoof-shaped structures (conks) at the base of the tree (Figure 40).	Avoid mechanical wounds to the base of the tree. No control is available once infection has occurred. Trees that are a structural risk should be removed. See general discussion of wood decay on Page 9 for more information.
	Squirrel damage	Squirrels chew bark strips off causing twig and branch dieback. Occurs in occasional years.	No management. See comments on animal damage on Page 5.
	Twig blight *Botryosphaeria*	Dieback of small twigs and medium-sized branches. Associated with stress.	Minor damage, no management needed.
	Witches broom associated with an interaction of a powdery mildew fungus (*Podosphaera phytoptophila*) and an eriophyid mite (*Aceria celtis*)	Affected branches develop abnormal swelling and a proliferation of lateral shoots. Brooms most visible during winter. Bud scales may be loose. Mites and powdery mildew cleistothecia may be visible in dissected buds viewed under magnification.	Does not damage tree health. Cut off affected branches.
	Hackberry nipple gall maker *Pachypsylla celtidismamma*	Galls, which are primarily present on leaf undersides, are approximately 0.2 inches in diameter and 0.25 high (Figure 87). The galls are evident on hackberry trees during summer. These galls are caused by a psyllid or jumping plant lice.	There is no cure or effective control strategy for hackberry nipple gall maker. In addition, infestations do not impact plant health. See general discussion of galls on Page 15.
Hawthorn *Crateagus*	Leafspot *Diplocarpon mespili,* also called *Entomosporium mespili*	Red to black angular spots develop on leaves. Leaves may turn yellow. Extensive leaf spotting will cause early defoliation. Succulent twigs can also become infected. Most common in wet, cool years.	Rarely damaging, primarily cosmetic, no management necessary. See general discussion of leaf spots on Page 6 for more information. In sites with severe disease, rake and discard or destroy dead leaves each fall. For sites with a chronic, severe problem fungicides may be useful.

Host	Diseases and Environmental Stresses	Symptoms/Identification	Comments
Hawthorn, cont.	Fire blight *Erwinia amylovora*	Sudden browning and wilting of branch spurs (Figure 91) or new shoot growth. Tips of blighted shoots curl, giving appearance of a "shepherd's crook" (Figure 92). Inner bark tissue turns water soaked with red-to-black discoloration. Cankers form on affected branches. Favored by wet spring weather.	Prune out affected branches at least 12 inches below visible damage. Sanitize tools between cuts. See further discussion of fire blight under crabapple.
	Rust – hawthorn rust *Gymnosporangium globosum*	Yellow-orange spots develop on leaves. Cup-like structures develop on leaf undersides. Leaves may turn yellow and drop prematurely.	See comments in table under crabapple and general discussion of rusts on Page 7.
	Rust – quince rust *Gymnosporangium clavipes*	Small, pinkish-white tubes protrude from fruit (Figure 28). Orange powder-like spores may dislodge from tubes when touched. Swelling and distortion of thorns, petioles, and succulent stems and twigs (Figure 27). Affected shoots and twigs eventually exhibit dieback.	See comments in table under crabapple and general discussion of rusts on Page 7.
	Lace bug *Corythucha cydoniae* (see Page 12)	Damage appears as light-yellow mottling or stippling on the upper leaf surface. Black eggs and nymphs, and lacy-appearing adults may be present on leaf undersides (Figures 64 – 66).	In general, lace bugs will not severely damage plants although extensive populations may reduce aesthetic appearance. Contact insecticides may be used; however, thorough coverage of the leaf undersides is important.
Hickory and pecan *Carya*	Leaf spots, anthracnose various fungi	Round, brown spots (lesions) develop on foliage.	Rarely damaging, primarily cosmetic, no management needed. See general discussion of leaf spots and anthracnose on Page 6 for more information.

Host	Diseases and Environmental Stresses	Symptoms/Identification	Comments
Hickory and pecan, cont.	Crown gall *Agrobacterium tumefaciens*	Large woody galls develop, usually on root collar or roots (Figure 38). Galls reduce plant vigor and eventually can kill plant. Causal bacterium persists long term in soil at the site.	Avoid planting infected materials. Inspect before purchasing/planting. Remove and destroy entire infected plants. Do not simply prune out galls. Do not replant with a susceptible host. See further details in general discussion of crown gall on Page 8.
	Pecan scab *Cladosporium caryigenum,* also called *Fusicladium effusum*	The disease causes rough, green to black spots on leaves and nuts of pecan. The disease is occasional in Kansas.	Rarely damaging on landscape trees, no management needed. Contact your local extension office for further information on commercial pecan production.
	Fall webworm *Hyphantria cunea* (see Page 11)	Create large nests or webbing in tree branches. Caterpillars, which are yellow-green to brown in color with black spots, remain in the nests feeding (Figures 56 – 58).	Prune out localized nests or webbing and dispose of immediately. Use a rake to disrupt the nest, which will allow birds to feed on the caterpillars.
Holly *Ilex*	Canker and twig dieback various fungi	Lesions form on branches and cause dieback.	Prune out infected branches. Maintain shrub health with proper pruning, fertilization, and irrigation. See general comments on cankers on Page 8.
	Environmental scorch	Leaf margins and/or entire leaves turn brown and dry (scorched) during dry, windy conditions (Figure 1).	Provide adequate water. Use mulches to help retain soil moisture. See general discussion of environmental scorch on Page 2.
	Leaf spots various fungi	Round, brown spots (lesions) develop on foliage.	Rarely damaging, primarily cosmetic, no management needed. See general discussion of leaf spots on Page 6 for more information.
	Spine spot mechanical damage	Small, gray spots with purple halos are caused by spines puncturing leaves. Very common.	Primarily cosmetic, not damaging to plant, no management needed.

Host	Diseases and Environmental Stresses	Symptoms/Identification	Comments
Honeylocust *Gleditsia triacanthos*	Canker *Nectria/ Thyronectria*	Branch dieback, reduced foliage and premature defoliation. Sunken, dark-red cankers form in branch crotches or at pruning wounds (Figure 34). Young trees may die rapidly while mature trees may remain in a weakened state for many years. Common in trees stressed by drought or over-irrigation.	Maintain tree health with proper pruning, fertilization and irrigation. Avoid mechanical wounds to the trunk. Prune out all cankered branches to 1 foot below visible damage. Some cultivars are more susceptible than others.
	Honeylocust knot Suspected to be caused by a bacterium and/or herbicide damage, but causation not fully understood.	Small, swollen galls at branch nodes. Shoot blighting also may occur.	In many cases this condition does not affect tree vigor, just causes unattractive knots. In cases with shoot blighting, affected branches can be pruned out. Sanitize tools between cuts using 70 percent alcohol or 10 percent bleach (dip tools in oil afterwards to prevent corrosion). Avoid planting nursery stock with symptoms.
	Leaf spot *Linospora gleditsiae*	Numerous small black spots clustered in a group. Some leaf yellowing and shedding.	Rarely damaging, primarily cosmetic, no management needed. See discussion of leaf spots on Page 6.
	Wood decay/root rot *Ganoderma* and various other fungi	Tree may show dieback/decline. Decayed wood. *Ganoderma* produces reddish-brown conks (fruiting structures) on roots and the lower trunk (Figure 40). Other fungi may produce white spongy growth at the base of the tree.	Fungus enters through wounds, therefore prevent wounds to trees during planting and maintenance. There is no control once the fungus has colonized the wood. Trees with indications of decay should be evaluated by a tree-care professional. Trees that are a structural risk should be removed by a certified arborist. See general discussion of wood decay on Page 9 for more information.
	Mimosa webworm *Homadaula anisocentra*	Larvae, which are ½ inch long, and green in color, web leaves together on the ends of branches. Heavily-infested trees appear brown or scorched (Figure 95).	Contact or stomach poison insecticides need to be applied at the first sign of caterpillars. Once damage is noticeable, it may be too late to initiate any type of control strategy.

Host	Diseases and Environmental Stresses	Symptoms/Identification	Comments
Honeylocust, cont.	Bagworm *Thyridopteryx ephemeraeformis* (see Page 11)	Caterpillars create small bags or cases covered with material from host plant. Feeding causes browning of leaf tips. Young caterpillars are ⅛ to ¼ inch long whereas the mature caterpillar bags are 1 to 2 inches long (Figures 52 – 53).	Can cause substantial damage if not dealt with. Contact or stomach poison insecticides may be used to deal with extensive infestations. Removing female bags by hand in the winter may be effective in reducing caterpillar populations the following season.
Honeysuckle *Lonicera* ***Note:*** Bush honeysuckles (Amur honeysuckle — *Lonicera maackii* and Bella honeysuckle — *Lonicera x bella*) are problematic invasive weeds and should not be planted.	Environmental scorch	Leaf margins and/or entire leaves turn brown and dry (scorched) during dry, windy conditions (Figure 1).	Provide adequate water. Use mulches to help retain soil moisture. See general discussion of environmental scorch on Page 2.
	Iron chlorosis	Yellowing of leaf tissue between veins; veins remain green (Figure 5).	Avoid planting susceptible species in high pH soils. In severe cases provide iron with injections. See general discussion of iron chlorosis on Page 4.
	Leaf blight *Insolibasidium deformans*	This disease first appears on newly-developing leaves in the spring. Affected leaves turn tan then become dry and brittle. Leaves often twist or curl and drop prematurely. A white, powdery mass of the fungus forms on the lower surface of the leaf, in contrast to powdery mildew, which is primarily on the upper surface.	Rarely damaging. If disease occurs, rake and discard diseased leaves in the fall.
	Powdery mildew	Leaf yellowing and minor leaf shedding. Most common in humid conditions. Unlike other powdery mildews, fungal growth is rarely visible on leaves.	Rarely damaging, primarily cosmetic, no management necessary. Improving airflow may reduce severity. See general discussion of powdery mildew on Page 7.
	Honeysuckle witches-broom aphid *Hyadaphis tataricae*	New growth is stunted with distinct clusters ("witches broom") on the ends of branches. Plants appear red-streaked, and leaves are curled and smaller than normal. See discussion of aphids on Page 12.	Use resistant varieties of honeysuckle. Systemic insecticides can be applied in spring when new leaves are expanding and before newly-hatched aphids initiate feeding. Once damage is noticeable, it is generally too late to initiate any type of control strategy.

Host	Diseases and Environmental Stresses	Symptoms/Identification	Comments
Horse chestnut *Aesculus*	Environmental scorch	Leaf margins and/or entire leaves turn brown and dry (scorched) during dry, windy conditions (Figure 1).	Provide adequate water. Use mulches to help retain soil moisture. See general discussion of environmental scorch on Page 2.
	Leaf blotch *Guignardia aesculi*	Large, brown, irregular blotches on leaves, sometimes limited by veins. Blotches often have a yellow border. Dark fruiting bodies may be visible. Affected leaves may become shriveled or distorted. Severe infections cause premature defoliation. Most common in wet weather.	Generally occurs late in summer. Rarely damaging. No management needed.
	Rust *Aecidium aesculi*	Orange spots and pustules develop on foliage. Primarily in wet years.	Rarely damaging, primarily cosmetic. No management needed.
Hydrangea *Hydrangea*	Bacterial leaf spot *Xanthomonas campestris*	Angular leaf spots are initially water-soaked then turn brown. Leaf spots may have yellow halo (Figure 97).	Rarely damaging, primarily cosmetic. Most common in very wet years. Avoid overhead irrigation. Improve airflow to promote drying. Avoid working on plants when they are wet. If practical, remove diseased leaves and discard.
	Botrytis bud blight/gray mold *Botrytis cinerea*	Buds and flowers discolor and die rapidly. Gray, fuzzy fungal growth may be visible. The fungus primarily invades senescing, wounded, or overly-succulent tissue.	Most common in humid conditions. Avoid overhead irrigation. Improve airflow to promote drying. Avoid excessive fertilization.
	Cercospora leaf spot *Cercospora*	Purplish-brown lesions develop on leaves.	Rarely damaging, primarily cosmetic, no management needed. See general discussion of leaf spots on Page 6.
	Powdery mildew	White, powdery fungal growth develops on leaf surfaces.	Rarely damaging, primarily cosmetic, no management necessary. Improving airflow may reduce severity. See general discussion of powdery mildew on Page 7.

Host	Diseases and Environmental Stresses	Symptoms/Identification	Comments
Juniper *Juniper* Upright forms include: **Eastern red cedar** *Juniperus virginianae* **Rocky Mountain Juniper** *Juniperus scopulorum* Shrub and groundcover junipers: Various *Juniperus* species	Botryosphaeria canker *Botryosphaeria stevensii*	Rocky Mountain juniper is highly susceptible. Branch dieback and mortality. Branch dieback. Branch cankers are elliptical, flattened and often covered with resin. Cankers are difficult to detect unless the outer bark is removed. Branch cankers are frequently at the lower part of the branch, near the trunk. Common in eastern Kansas. Favored by wet weather.	Prune out diseased branches. Remove tree if more than one-half of the crown is affected. Do not plant Rocky Mountain juniper in eastern Kansas. Do not replant Rocky Mountain juniper in plantings where the disease is present.
	Cercospora needle blight *Cercospora sequoiae* var. *juniperi*	Lower, inner needles turn reddish-brown and drop in late summer or fall (Figure 102). If disease occurs for several years defoliation can become severe and kill plants. Most common in wet years. Potentially serious on Rocky Mountain juniper in eastern half of Kansas.	Select resistant varieties. Do not plant Rocky Mountain juniper in eastern Kansas. Space plants appropriately to allow airflow.
	Kabatina tip blight *Kabatina juniperi*	Infection period is in fall. Symptoms appear in spring, with upper 2 to 6 inches of branch tips turning red or yellow. Gray lesions develop at base of affected shoots. Affected tips dry out and drop off in late spring/early summer (Figures 98 – 99).	Space plants appropriately to allow air flow; avoid wounding plants; avoid irrigation that wets the foliage; prune out affected branch tips. Symptoms disappear when affected tips fall off on their own.
	Phomopsis tip blight *Phomopsis juniperovora*	Upper 4 to 6 inches of branch tips turn brown then gray, usually from late spring through early fall. Affected tips dry out and drop off (Figure 100). Fungal structures may be visible (Figure 101).	Space plants appropriately to allow air flow; avoid wounding plants; avoid irrigation that wets the foliage; prune out affected branch tips. Symptoms disappear when affected tips fall off on their own.
	Rust – cedar-apple rust *Gymnosporangium juniperi-virginianae*	Brown galls, ½ to 1 inch in diameter, develop on young shoots. In spring (usually April or May), gelatinous orange "horns" up to ¾ to 1 inch long, protrude from galls, producing spores (Figure 22). Galls survive 1 year.	Rarely damaging to juniper. No management needed. See general comments on rusts on Page 7.

Host	Diseases and Environmental Stresses	Symptoms/Identification	Comments
Juniper, cont.	Rust – hawthorn rust *Gymnosporangium globosum*	Brown galls, ¼ to ½ inch in diameter, develop on young shoots. In spring (usually April or May), gelatinous orange "horns" up to ¼ to ½ inch long, protrude from galls, producing spores (Figure 24). Galls survive several years.	Rarely damaging to juniper. No management needed. See general comments on rusts on Page 7.
	Rust – quince rust *Gymnosporangium clavipes*	Swollen twigs and branches. Cushion-like gelatinous orange slime develops during wet spring weather (usually April or May), producing spores (Figure 25). Infections can produce spores for several years. Cushions become crusty when dry (Figure 26).	Affected branches may die back to healthy point. Overall, little damage to tree. No management needed.
	Root rot/root decline	Branch dieback, general decline. Most common in low-growing shrub junipers. Can be caused be wet soils. Infection by *Phytophthora* also occurs under wet conditions and causes similar symptoms.	Avoid planting in areas with poor drainage. See discussion of wet soils on Page 3 and root rots on Page 9.
	Salt damage	Browning of foliage, tip dieback.	Junipers along roads and sidewalks are sensitive to deicing salts. See discussion of salt damage on Page 5.
	Seiridium canker *Seiridium unicorne*	Branches and stems develop long, flat cankers, sometimes with bleeding. Entire trees, sections of trees, or individual branches may turn dull green then brown in late spring or early summer. Most severe on exposed sites. Not common on juniper.	Winter injury and other abiotic issues make trees more susceptible to the canker. See general discussion of cankers on Page 8 and winter injury on Page 2. Prune out and remove cankered branches. Provide adequate water.
	Winter desiccation	Branches turn dull-green, then brown in March and April. Scorch. Foliage can also turn a dull green during winter months but does not die, leading to a temporary winter browning.	Very common. See general discussion of environmental scorch and winter injury on Page 2.
	Winter injury (winter kill)	Scorch and branch dieback.	Very common. See general discussion of environmental scorch and winter injury on Page 2.

Host	Diseases and Environmental Stresses	Symptoms/Identification	Comments
Juniper, cont.	Bagworm *Thyridopteryx ephemeraeformis* (see Page 11)	Caterpillars create small bags or cases covered with material from host plant. Feeding causes browning of the tips of needles. Young caterpillars are ⅛ to ¼ inch long whereas the mature caterpillar bags are 1 to 2 inches long (Figures 52 – 53).	Can cause substantial damage if not dealt with. Contact or stomach poison insecticides may be used to deal with extensive infestations. Removing female bags by hand in the winter may be effective in reducing caterpillar populations the following season.
Lilac *Syringa*	Bacterial shoot blight *Pseudomonas syringae*	Affected leaves and shoots first appear water-soaked but quickly darken and shrivel as if scorched by fire. Succulent growth is more susceptible. Most common in spring.	Prune out infected shoots 10 to 12 inches below visible symptoms and discard or destroy pruned materials. Disinfect pruning shears after each cut. Avoid pruning during wet weather. Some lilac cultivars have reduced susceptibility to bacterial shoot blight.
	Environmental scorch	Leaf margins and/or entire leaves turn brown and dry (scorched) during dry, windy conditions.	Provide adequate water. Use mulches to help retain soil moisture. See general discussion of environmental scorch on Page 2.
	Leaf spots several fungi	Round, brown spots (lesions) develop on foliage.	Rarely damaging, primarily cosmetic, no management needed. See general discussion of leaf spots on Page 6 for more information.
	Powdery mildew	White, powdery fungal growth develops on leaf surfaces.	Rarely damaging, primarily cosmetic, no management necessary. Improving airflow may reduce severity. See general discussion of powdery mildew on Page 7.
	Ramorum blight also called sudden oak death *Phytophthora ramorum*	Large necrotic (brown) blotches on foliage. Shoot dieback. Blackening of leaf stems and succulent shoots. Defoliation. Most likely under wet conditions.	**Not known to occur in Kansas but could become introduced.** Most likely to be introduced on nursery stock. Avoid purchasing and planting suspect material. Contact KSU Plant Disease Diagnostic Clinic to report suspect plants.

Host	Diseases and Environmental Stresses	Symptoms/Identification	Comments
Lilac, cont.	Ash/lilac borer *Podosesia syringae*	Larvae cause plant injury by tunneling and feeding within trees, which causes isolated branch dieback. Pupal cases may be noticed protruding from infested trees. Adults are clear-wing moths. Light-colored sawdust may also be present at the base of infested trees (Figures 83 – 85).	Maintain plant health through proper watering, fertilization, pruning, and mulching. A contact insecticide may be applied to the bark in early spring to kill adults that emerge from trees and larvae that hatch from eggs. See Page 15.
	Oystershell scale *Lepidoasaphes ulmi*	Scales are around 0.1 inch long, gray or brown in color, and shaped like oyster shells. Branches or twigs can be totally encrusted with oyster-shell scales. Causes twig and branch dieback.	Prune out heavily-infested branches or twigs. Contact insecticides may be used; however, applications are most effective when crawlers are present. Use double-sided sticky tape wrapped around branches to assess when crawlers are active.
Linden *Tilia*	Leaf spots Several fungi	Round, brown spots (lesions) develop on foliage. Primarily occurs in the fall.	Rarely damaging, primarily cosmetic, no management needed. See general discussion of leaf spots on Page 6 for more information.
	Environmental scorch	Leaf margins and/or entire leaves turn brown and dry (scorched) during dry, windy conditions.	Provide adequate water. Use mulches to help retain soil moisture. See general discussion of environmental scorch on Page 2.
	Lace bug *Corythucha cydoniae* (see Page 12)	Damage appears as light-yellow mottling or stippling on the upper leaf surface. Black eggs and nymphs, and lacy-appearing adults may be present on leaf undersides (Figures 64 – 66).	In general, lace bugs will not severely damage plants although extensive populations may reduce aesthetic appearance. Contact insecticides may be used; however, thorough coverage of the leaf undersides is important.
	Japanese beetle *Popillia japonica* (see Page 10)	Adults are metallic green beetles with coppery-brown wing covers, and white tufts of hair at the end of the abdomen (Figure 48). Feeding damage starts at the top of trees. Leaves fed upon by adults appear lace-like or skeletonized with the veins intact.	Apply contact insecticides when adults are active. Multiple applications will be required.
London plane tree – see Sycamore			

Host	Diseases and Environmental Stresses	Symptoms/Identification	Comments
Maple *Acer*	Anthracnose *Discula*	Reddish to black spots or blotches form on leaves in the spring, particularly during wet, cool weather. Typically, the spots are formed along the veins. Severe infection may cause premature leaf shedding.	Rarely damaging, primarily cosmetic, no management needed. See general comments on anthracnose diseases on Page 6.
	Environmental scorch	Leaf margins and/or entire leaves turn brown and dry (scorched) during dry, windy conditions (Figure 1).	Provide adequate water. Use mulches to help retain soil moisture. See general discussion of environmental scorch on Page 2.
	Iron chlorosis	Yellowing of leaf tissue between veins; veins remain green (Figure 5).	Avoid planting susceptible species in high pH soils. In severe cases provide iron with injections. See general discussion of iron chlorosis on Page 4.
	Leaf blister *Taphrina* spp.	Light-green blisters develop on the leaves. The blisters eventually turn brown. Hard maples are more susceptible.	Rarely damaging, primarily cosmetic, no management needed.
	Leaf spots: Tar spot (*Rhytisma*), purple eyespot (*Phyllosticta*)	Several leaf spots occur on maple, but generally do little damage to the tree.	Rarely damaging, primarily cosmetic, no management needed. See general discussion of leaf spots on Page 6.
	Root rot and butt rots many fungi including *Armillaria mellea, Ganoderma lucidum*	White spongy rot of the roots and root collar. Conks or mushrooms may be evident at the base of the tree (Figures 40 – 41).	Fungus enters through wounds and branch stubs, therefore prevent wounds to trees and prune properly. There is no control once the fungus has colonized the wood. Trees with indications of decay should be evaluated by a tree-care professional. Trees that are a structural risk should be removed by a certified arborist. See general discussion of wood decay on Page 9 for more information.

Host	Diseases and Environmental Stresses	Symptoms/Identification	Comments
Maple, cont.	Verticillium wilt *Verticillium dahliae*	Wilting, yellowing, decline, dieback (Figure 31). Vascular discoloration (brown streaking) may be visible when viewing cross-section of cut branches or when bark is removed (Figure 32).	Maintain overall plant health with appropriate watering, fertilization, etc. Do not replant a susceptible species into a site with history of Verticillium wilt. See general discussion of Verticillium wilt on Page 8.
	Bacterial wetwood Several bacterial species	Liquid oozes from wounds and cracks and runs down bark, leaving discolored streaks on branches or trunk (Figure 42).	Rarely damaging, primarily cosmetic, management not necessary. See general discussion of wetwood on Page 9.
	Winter injury (winter kill)	Branch dieback.	See general discussion of environmental scorch and winter injury on Page 2.
Mulberry *Morus rubra*	Leaf spot *Cercospora* spp.	Reddish brown spots on leaves. Occurs during wet weather.	Rarely damaging, primarily cosmetic, no management needed. See general discussion of leaf spots on Page 6.
	Powdery mildew	White, powdery fungal growth develops on leaf surfaces.	Rarely damaging, primarily cosmetic, no management necessary. Improving airflow may reduce severity. See general discussion of powdery mildew on Page 7.
	Popcorn Disease *Ciboria carunculoides*	The fruit is replaced by hard fungal structures resembling popcorn seeds.	This disease does not cause permanent damage and control is not necessary.
	Twig dieback	This problem is associated with freeze injury although weak pathogens may attack the weakened twigs.	Keep trees vigorous by proper fertilization and watering. Prune out dead twigs in late winter or early spring.
	Bacterial wetwood several bacterial species	Liquid oozes from wounds and cracks and runs down bark, leaving discolored streaks on branches or trunk (Figure 42).	Rarely damaging, primarily cosmetic, management not necessary. See general discussion of wetwood on Page 9.

Host	Diseases and Environmental Stresses	Symptoms/Identification	Comments
Oak *Quercus*	Anthracnose *Gnomonia quercina*	Irregular brown dead areas on the leaves along the veins. Affected leaves appear scorched starting from the tip. Defoliation may be light to heavy and some twig dieback may occur. The disease is favored by wet, cool spring weather. Anthracnose is most serious on white oaks (Figures 107 – 108).	Rarely damaging, primarily cosmetic, no management needed. See general comments on anthracnose on Page 6.
	Biscogniauxia canker/Hypoxylon canker *Biscogniauxia/ Hypoxylon*	The fungus colonizes weakened, declining trees. Early decline symptoms include yellowing and wilting of leaves on upper branches. Branch dieback occurs and eventually outer bark is sloughed off. When the bark is gone, a crust of fungal material (stroma) is exposed. The color of this mass changes from brown to silver to black (Figure 36).	Maintain overall plant health with proper pruning, fertilization and irrigation. There is no control for this disease once it becomes established in the tree. Remove dead tree to the ground, leaving no stump, and burn the wood immediately. See discussion of cankers on Page 8.
	Bur oak blight – see leaf spot		
	Endothia canker *Endothia gyrosa*	Sunken areas in bark on trunks or branches. Orange, red, or brown fungal fruiting structures may be present (Figure 35). Branch dieback/decline.	Maintain overall plant health with proper pruning, fertilization and irrigation. Prune out cankered or dead limbs. See general comments on cankers on Page 8.
	Environmental scorch	Leaf margins and/or entire leaves turn brown and dry (scorched) during dry, windy conditions (Figure 1).	Provide adequate water. Use mulches to help retain soil moisture. See general discussion of environmental scorch on Page 2.
	Iron chlorosis	Yellowing of leaf tissue between veins; veins remain green.	Avoid planting susceptible species in high pH soils. In severe cases provide iron with injections. See general discussion of iron chlorosis on Page 4.
	Leaf blister *Taphrina caerulescens*	The disease first appears as light green blisters on the leaves. Blisters may enlarge and affected leaf tissue turns brown. Leaf blister only occurs during wet, cool springs.	Rarely damaging, primarily cosmetic, no management needed. Most common in wet years.

Host	Diseases and Environmental Stresses	Symptoms/Identification	Comments
Oak, cont.	Leaf spot/blight *Tubakia/Actinopelte*	Small dark spots on leaves between the veins. Some spots may have a light brown center. Spots may also coalesce and form large irregular patches (Figure 104). Pin oak is more susceptible than other oaks. Bur oak blight is caused by a related fungus. Necrosis develops along veins. Leaves may develop a scorched appearance starting from the tip. Black fruiting structures may be visible on petioles. Infected trees retain some infected leaves and petioles. Can be damaging on bur oaks mid-to-late season in very wet years.	Rarely damaging, primarily cosmetic, no management needed. Most common in wet years. Bur oak blight can be more severe, with tree decline. Promoting overall tree vigor may be reduce stress.
	Oak wilt *Ceratocystis fagacearum*	Red oak group much more susceptible than white oak group. Early symptoms are wilting leaves on individual branches in the upper portion of the tree in late May or June. Individual leaves bronze from the margins inward and the tip downwards to the petiole Half leaf scorch is common. Wilting progresses down the tree. If the bark on affected branches is pulled back, brown streaks are evident in the sapwood. Branch samples containing streaks should be submitted to the diagnostic lab for confirmation of the disease. Infected trees die in 1 to 2 years (Figures 105 – 106).	Currently occurs in eastern quarter to third of Kansas. Prune when trees are dormant. Avoid pruning from March through July. Diseased trees should be removed and destroyed, but root grafts should be disrupted first to prevent spread. Wood should not be saved for firewood.
	Powdery mildew	White, powdery fungal growth develops on leaf surfaces.	Rarely damaging, primarily cosmetic, no management necessary. Improving airflow may reduce severity. See general discussion of powdery mildew on Page 7.

Host	Diseases and Environmental Stresses	Symptoms/Identification	Comments
Oak, cont.	Root rot *Armillaria mellea*, others	Oaks show a general decline. The wood decays at the base of the tree. In the case of *Armillaria*, if the bark is pulled back, black fungal shoestring-like growth (rhizomorphs) can be observed (Figure 41). In the fall yellow to tan (orange) mushrooms are seen at the base of the tree.	Maintain tree health with appropriate watering pruning, and irrigation. When removing an infected tree, remove the butt and larger roots and do not plant another tree at the same site. See discussion of wood decay on Page 9.
	Sooty mold fungi	Black moldy growth on the leaf surface. The fungi growing on the leaves are not parasitic to the plant, they are saprophytes living on insect (ex: aphid, scale) honeydew.	Sooty mold does not cause serious injury and control of the fungus is not necessary; however, the presence of sooty mold can be an indication of heavy insect activity.
	Bacterial wetwood several bacterial species	Liquid oozes from wounds and cracks and runs down bark, leaving discolored streaks on branches or trunk (Figure 42).	Rarely damaging, primarily cosmetic, management not necessary. See general discussion of wetwood on Page 9.
	Wood decay/butt rots Various fungi	Branch dieback, discolored wood, decayed wood, fruiting structures (mushrooms, conks).	Fungus enters through wounds and branch stubs, therefore prevent wounds to trees and prune properly. There is no control once the fungus has colonized the wood. Trees with indications of decay should be evaluated by a tree-care professional. Trees that are a structural risk should be removed by a certified arborist. See general discussion of wood decay on Page 9 for more information.
	Oak lace bug *Corythucha arculata* (see Page 12)	Damage appears as light-yellow mottling or stippling on the upper leaf surface. Black eggs and nymphs, and lacy-appearing adults may be present on leaf undersides (Figures 64 – 66).	In general, lace bugs will not severely damage plants although extensive populations may reduce aesthetic appearance. Contact insecticides may be used; however, thorough coverage of the leaf undersides is important.

Host	Diseases and Environmental Stresses	Symptoms/Identification	Comments
Oak, cont.	Obscure scale *Melanaspis obscura*	Heavy infestations may encrust the entire trunk and branches of plants. Leaves may appear yellow in color (Figure 67).	Contact insecticides must be applied as soon as eggs hatch and crawlers are active. After this, it is too late to initiate any control strategy. Maintain proper plant health by providing adequate watering and mulch around the base of plants. Removing scales from the trunk by scraping may be effective. See Page 13.
	Oak kermes scale *Kermes pubescens*	Scales are usually present on the ends of branches at the base of small twigs causing dieback of branches. They resemble oak galls. May produce honeydew, a sticky liquid (Figure 69).	In general, will not kill plants but heavy infestations may reduce aesthetic appearance. Prune out heavily-infested branches or twigs. Insecticides may be used but must be applied when crawlers are active. See Page 13.
	Galls Various species	Several insect and mite species cause galling on oak leaves and twigs.	Rarely damaging, primarily cosmetic. No management needed. See Page 15.
	Winter injury	Twig and branch dieback. Can predispose trees to Nectria canker (see above).	See general discussion of winter injury on Page 2.
Peach flowering/ornamental – see Cherry			
Pear flowering/ornamental including Bradford pear and Callery pear For trees grown for fruit production, other references are available. Contact your local extension office for information.	Environmental scorch	Leaf margins and/or entire leaves turn brown and dry (scorched) during dry, windy conditions (Figure 1). Can be confused with bacterial shoot blights, but scorch occurs during hot/dry weather, not wet spring weather.	Provide adequate water. Use mulches to help retain soil moisture. See general discussion of environmental scorch on Page 2.
	Bacterial shoot blights Fire blight *Erwinia amylovora* Pseudomonas blight *Pseudomonas syringae*	Blighting of new leaves and shoots during wet weather in May and June; affected leaves turn black at the margins or along the veins (Figures 91 – 92).	Prune out diseased shoots during hot, dry periods, cutting at least 6 to 8 inches below visible blighting. Avoid excessive fertilization.

Host	Diseases and Environmental Stresses	Symptoms/Identification	Comments
Pear, cont.	Rust *Gymnosporangium*	Yellow-orange spots develop on leaves. Cup-like structures develop on leaf undersides. Defoliation can occur in severe cases.	See crabapple and general discussion and images of "cedar-apple rusts" on Page 7.
Pecan – see Hickory			
Photinia	Environmental scorch	Leaf margins and/or entire leaves turn brown and dry (scorched) during dry, windy conditions (Figure 1).	Provide adequate water. Use mulches to help retain soil moisture. See general discussion of environmental scorch on Page 2.
	Fire blight *Erwinia amylovora*	Sudden browning and wilting of branch spurs (Figure 91) or new shoot growth. Tips of blighted shoots curl, giving appearance of a "shepherd's crook" (Figure 92). Inner bark tissue turns water soaked with red-to-black discoloration. Cankers form on affected branches. Favored by wet spring weather.	Prune out affected branches at least 12 inches below visible damage. Sanitize tools between cuts. See further discussion of fire blight under crabapple.
	Leaf spot *Entomosporium mespili* also called *Diplocarpon mespili*	Symptoms start as small red dots, developing into ¼ inch leaf spots with purplish borders. Black dots (fruiting structures) maybe be visible. Severe infections can lead to defoliation.	Rarely damaging, management not needed. Disease most susceptible in succulent tissue so avoid summer pruning and excessive fertility. See general discussion of leaf spots on Page 6.
	Powdery mildew	White, powdery fungal growth develops on leaf surfaces.	Rarely damaging, primarily cosmetic, no management necessary. Improving airflow may reduce severity. See general discussion of powdery mildew on Page 7.
	Lace bug *Corythucha* spp.	Damage appears as light-yellow mottling or stippling on the upper leaf surface. Black eggs and nymphs, and lacy-appearing adults may be present on leaf undersides (Figures 64 – 66).	In general, lace bugs will not severely damage plants although extensive populations may reduce aesthetic appearance. Contact insecticides may be used; however, thorough coverage of the leaf undersides is important. See Page 12.

Host	Diseases and Environmental Stresses	Symptoms/Identification	Comments
Pieris	Ramorum blight also called sudden oak death *Phytophthora ramorum*	Large necrotic (brown) blotches on foliage. Shoot dieback. Blackening of leaf stems and succulent shoots. Defoliation. Most likely to occur in wet conditions.	**Not known to occur in Kansas but could become introduced.** Most likely to be introduced on nursery stock. Avoid purchasing and planting suspect material. Contact KSU Plant Disease Diagnostic Clinic to report suspect plants.
Pine *Pinus*	Brown spot *Scirrhia acicola* also called *Mycosphaerella dearnessii* and *Eruptio acicola*	Infection occurs primarily in wet weather in spring and early summer. Needle spotting and partial needle scorch in summer. Needle browning and needle drop in fall/winter. Most prevalent on lower, interior foliage. Most common on Scots Pine, especially when grown in Christmas tree plantations. Also can occur on ponderosa pine.	Promote good air circulation with adequate tree spacing, pruning, and weed management around trees in plantations. In cases of severe, chronic disease, spring fungicides may be beneficial. Contact your local extension office for information.
	Drought stress	Tree decline and branch dieback. Most common in Scots and white pine.	Easily confused with pine wilt. See general comments on drought stress and environmental scorch on Page 2.
	Environmental scorch Needle scorch	Needles die from the tip back while the base remains green. Occurs during periods of dry, windy weather in both summer (hot temperatures) and winter (cold temperatures) (Figure 2).	Provide adequate water. See general discussion of environmental scorch and winter desiccation on Page 2.
	Iron chlorosis	Yellowing of needles. Primarily on white pine.	Avoid planting susceptible species in high pH soils. In severe cases provide iron with injections. See general discussion of iron chlorosis on Page 4.
	Natural needle drop	Two- to four-year needles on the inside of the tree turn yellow then brown and drop off in fall. Needle shed is more prevalent with stress caused by heat and drought.	This phenomenon is a natural occurrence in pines.

Host	Diseases and Environmental Stresses	Symptoms/Identification	Comments
Pine, cont.	Needle blight/ needle cast *Dothistroma pini* *Dothistroma septosporum*, also called *Mycosphaerella pini*, may also occur but has not been confirmed in Kansas	Scattered yellow or tan spots appear on interior needles in late summer or early fall. Spots often enlarge into red bands that encircle the needles. Needles then turn yellow from the band to the tip. Black fruiting bodies are formed in the band during late winter or early spring and summer (Figure 15a). Extensive needle drop in interior needles, leaving only the current season's growth (Figure 111). Chronic disease in successive years can leave the interior lower third of the tree bare of needles. Needle blight is a serious disease on Austrian and ponderosa pine. Mugo pine is also susceptible but Scots pine is considered resistant.	Most common in crowded plantings. Provide adequate spacing for improved airflow. Raking up fallen diseased needles may reduce disease pressure. Spring fungicides may beneficial in sites with chronic, severe disease. Contact your local extension office for information.
	Needle rust *Coleosporium*	White, bubble-like pustules with powdery orange spores develop on needles.	Rare. Primarily on loblolly pine.
	Pine wilt Pinewood nematode *Bursaphelenchus xylophilus*	Foliage turns gray-green then brown. Reduction/cessation of resin flow. Individual branches dieback with entire tree dying over weeks to months, or entire tree can die quickly. Affected trees usually die in several weeks to a few months. Infection often occurs in early summer with symptoms and tree death appearing in late summer/early fall (Figure 33).	Nematode is spread to new trees by the pine sawyer beetle. Remove and destroy infected trees through chipping or burning by April 1 of the following year to prevent further spread by the sawyer beetle. Injectable chemicals are available that may reduce disease risk when used preventatively. Contact your local extension office for information. See Page 8 for further discussion.

Host	Diseases and Environmental Stresses	Symptoms/Identification	Comments
Pine, cont.	Tip blight *Diplodia pinea* also called *Sphaeropsis sapinea*	Infections occur during rainy spring weather. Symptoms first appear in late May or early June. New candles (shoots) fail to elongate and turn yellow or tan (Figure 109). Small droplets of resin often form on stunted needles. Needles normally remain attached to the branch. In late summer, small black fruiting bodies develop at the base of infected needles and on cone scales (Figure 110). Austrian, ponderosa, Scots and Mugo pine are all susceptible. The fungus can also develop a canker infection in older wood, especially in wounded or drought-stressed trees. Cankers on the branches or trunk produce abundant resin.	Maintain overall plant health with appropriate watering, fertilizing, etc. Promote airflow with appropriate tree spacing. If disease becomes established in a tree spring fungicide applications starting at candle elongation may reduce disease. May need to be applied for several years in a row.
	Western gall rust *Peridermium harknessii* also called *Endocronartium harknessii*	Rare in Kansas. Large galls develop on the branches and trunks of trees. In the spring, galls break open and expose bright orange, dusty spores. Scots and ponderosa pines are most susceptible.	Inspect and discard all nursery stock with galls. On larger trees, prune off branches with galls. Trees with galls on the main stem should be removed.
	Wet soil	General tree decline, branch dieback.	Avoid planting pines in wet sites. See Page 3.
	Pine needle scale *Chionaspis pinifoliae* (see Page 12)	May completely cover needles causing chlorosis and premature needle drop. In addition, heavy infestations can reduce the aesthetic appearance of plants.	Contact insecticides may used but should be applied as soon as crawlers are active. Scales are susceptible to natural enemies such as parasitoids; however, these may not kill enough scales to prevent damage from occurring.
	European pine sawfly *Neodiprion sertifer* (see Page 11)	Larvae feed in groups on previous year's needles before new growth expands and consume the needles on a branch turning them completely brown (Figures 60).	Contact insecticides may be used as soon as the larvae are present in early spring. Larvae can also be removed by hand and placed into a container of soapy water.

Host	Diseases and Environmental Stresses	Symptoms/Identification	Comments
Pine, cont.	Bagworm *Thyridopteryx ephemeraeformis* (see Page 11)	Caterpillars create small bags or cases covered with material from host plant. Feeding causes browning of needle tips. Young caterpillars are ⅛ to ¼ inch long whereas the mature caterpillar bags are 1 to 2 inches long (Figures 52 – 53).	Can cause substantial damage if not dealt with. Contact or stomach poison insecticides may be used to deal with extensive infestations. Removing female bags by hand in the winter may be effective in reducing caterpillar populations the following season.
Plane tree – see Sycamore			
Poplar *Populus* and related trees including: **Cottonwood** *Populus deltoides* **Willows** *Salix*	Bacterial wetwood several bacterial species	Liquid oozes from wounds and cracks and runs down bark, leaving discolored streaks on branches or trunk (Figure 42).	Rarely damaging, primarily cosmetic, management not necessary. See general discussion of wetwood on Page 9.
	Crown gall *Agrobacterium tumefaciens*	Large woody galls develop, usually on root collar or roots (Figure 38). Galls reduce plant vigor and eventually can kill plant. Causal bacterium persists long term in soil at the site.	Avoid planting infected materials. Inspect before purchasing/planting. Remove and destroy entire infected plants. Do not simply prune out galls. Do not replant with a susceptible host. See further details in general discussion of crown gall on Page 8.
	Canker *Leucostoma, Valsa, Cytospora*	Brown sunken cankers on twigs and branches. Cankers may enlarge and girdle the branch. Fungal spores ooze out of pycnidia (fungal fruiting structures) in red, threadlike masses. Most common in trees with stress or injuries.	Maintain overall plant health with proper pruning, fertilization and irrigation. See general discussion of cankers on Page 8. If cankers develop, prune out and remove or destroy affected wood.
	Iron chlorosis	Yellowing of leaf tissue between veins; veins remain green.	Avoid planting susceptible species in high pH soils. In severe cases provide iron with injections. See general discussion of iron chlorosis on Page 4.
	Leaf spots *Marsonnina, Septoria,* and others	Small dark spots on leaves. Septoria spots often develop a gray center. These leaf spots occur during wet summer weather and generally do not cause serious damage. Minor leaf shedding may occur.	Rarely damaging, primarily cosmetic, management not needed. See general comments on leaf spots on Page 6.

Host	Diseases and Environmental Stresses	Symptoms/Identification	Comments
Poplar, cont.	Rust *Melampsora* spp.	Yellow-orange powdery spots on the underside of leaves develop from June through September. Occurs primarily during wet summers. Minor leaf shedding may occur.	Rarely damaging, primarily cosmetic, management not needed. See general comments on leaf spots and rusts on Pages 6 and 7.
	Bacterial wetwood several bacterial species	Liquid oozes from wounds and cracks and runs down bark, leaving discolored streaks on branches or trunk (Figure 42).	Rarely damaging, primarily cosmetic, management not necessary. See general discussion of wetwood on Page 9.
	Cottonwood borer *Plectrodera scalator*	Larvae damage the root crown and buttress roots of plants. This may result in girdling of plants. Adults feed on the bark and petioles. Heavy infestations of adults may result in defoliation of plants (Figures 75 – 76).	Maintain proper plant health by providing adequate watering and mulch around the base of plants. Prune out infested branches. Look for round-shaped exit holes in the bark.
Privet *Ligustrum*	Anthracnose and twig blight *Glomerella cingulata*	Leaf spots on foliage. Cankers develop on twigs causing dieback. The bark and wood of diseased areas turn brown. Pink fungal fruiting structures form in the dead bark.	Prune and remove infected twigs.
	Leaf spot *Cercospora* and others	Leaves develop small, circular spots. Severe leaf spotting may cause premature defoliation.	Rarely damaging, primarily cosmetic, no management needed. See general comments on leaf-spots on Page 6.
	Phomopsis galls associated with *Phomopsis* fungus, but true causation not well understood	Small galls form on the twigs and crown. May be confused with crown gall. (Figure 94).	Rarely damaging. Primarily cosmetic. Maintain overall plant vigor with proper watering, fertilization, etc. Avoid wounding plants. Prune out affected branches during dry weather at least 6 to 8 inches below gall.
	Powdery mildew	White, powdery fungal growth develops on leaf surfaces.	Rarely damaging, primarily cosmetic, no management necessary. Improving airflow may reduce severity. See general discussion of powdery mildew on Page 7.

Host	Diseases and Environmental Stresses	Symptoms/Identification	Comments
Pyracantha (firethorn) *Pyracantha*	Environmental scorch	Leaf margins and/or entire leaves turn brown and dry (scorched) during dry, windy conditions (Figure 1).	Provide adequate water. Use mulches to help retain soil moisture. See general discussion of environmental scorch on Page 2.
	Fire blight *Erwinia amylovora*	Sudden browning and wilting of branch spurs (Figure 91) or new shoot growth. Tips of blighted shoots curl, giving appearance of a "shepherd's crook" (Figure 92). Inner bark tissue turns water soaked with red-to-black discoloration. Cankers form on affected branches. Favored by wet spring weather.	Prune out affected branches at least 12 inches below visible damage. Sanitize tools between cuts. See further discussion of fire blight under crabapple.
	Iron chlorosis	Yellowing of leaf tissue between veins; veins remain green.	Avoid planting susceptible species in high pH soils. In severe cases provide iron with injections. See general discussion of iron chlorosis on Page 4.
Quince flowering/ ornamental *Cydonia*	Crown gall *Agrobacterium tumefaciens*	Large woody galls develop, usually on root collar or roots (Figure 38). Galls reduce plant vigor and eventually can kill plant. Causal bacterium persists long term in soil at the site.	Avoid planting infected materials. Inspect before purchasing/planting. Remove and destroy entire infected plants. Do not simply prune out galls. Do not replant with a susceptible host. See further details in general discussion of crown gall on Page 8.
	Fire blight *Erwinia amylovora*	Sudden browning and wilting of branch spurs (Figure 91) or new shoot growth. Tips of blighted shoots curl, giving appearance of a "shepherd's crook" (Figure 92). Inner bark tissue turns water soaked with red-to-black discoloration. Cankers form on affected branches. Favored by wet spring weather.	Prune out affected branches at least 12 inches below visible damage. Sanitize tools between cuts. See further discussion of fire blight under crabapple.
	Leaf spot various fungi	Small round brown spots develop on foliage. Leaf yellowing and shedding. Favored by wet conditions.	Rarely damaging, primarily cosmetic, no management needed. See general discussion of leaf spots on Page 6.

Host	Diseases and Environmental Stresses	Symptoms/Identification	Comments
Quince, cont.	Lace bug *Corythucha* spp. (see Page 12)	Damage appears as light-yellow mottling or stippling on the upper leaf surface. Black eggs and nymphs, and lacy-appearing adults may be present on leaf undersides (Figures 64 – 66).	In general, lace bugs will not severely damage plants although extensive populations may reduce aesthetic appearance. Contact insecticides may be used; however, thorough coverage of the leaf undersides is important.
Redbud *Cercis canadensis*	Verticillium wilt *Verticillium dahliae*	Wilting, yellowing, decline, dieback (Figure 31). Vascular discoloration (brown streaking) may be visible when viewing cross-section of cut branches or when bark is removed (Figure 32).	Maintain overall plant health with appropriate watering, fertilization, etc. Do not replant a susceptible species into a site with history of Verticillium wilt. See general discussion of Verticillium wilt on Page 8.
	Leaf spot *Cercospora* and others	Small reddish brown leaf spots with irregular margins. Occurs during wet years, primarily late in the growing season.	Rarely damaging, primarily cosmetic, no management needed. See general discussion of leaf spots on Page 6.
	Herbicide injury	Cupping or distortion of leaves, often caused by drift of phenoxy herbicides.	Primarily cosmetic, not damaging. See general discussion of herbicide injury on Page 4.
	Redbud leaffolder *Fascista cercerisella*	Causes leaves to fold over with distinct thickened white webbing located within the folds. Larvae have alternating black and white bands, and reside in the folded leaves (Figure 112).	In general, the damage will not kill plants although it may affect their aesthetic appearance. Contact insecticides will only be effective when applied early before leaves fold-over.
Rhododendron *Rhododendron* ***Note:*** Rhododendron is not adapted to the Kansas climate	Cankers *Botrysphaeria, Phomopsis,* and others	Leaves on individual branches droop and turn brown. Stem tissue turns dark brown. Branch dieback.	Maintain overall plant health with proper pruning, fertilization and irrigation. See general discussion of cankers on Page 8. If cankers develop, prune out and remove or destroy affected wood.
	Environmental scorch	Leaf margins and/or entire leaves turn brown and dry (scorched) during dry, windy conditions (Figure 1).	Provide adequate water. Use mulches to help retain soil moisture. See general discussion of environmental scorch on Page 2.

Host	Diseases and Environmental Stresses	Symptoms/Identification	Comments
Rhododendron, cont.	Leaf gall *Exobasidium vaccinii*	Pale green or white fleshy, distorted galls on foliage. Rare. Favored by wet conditions.	Hand removal or pruning of galled tissue may reduce disease.
	Leaf spots various fungi	Round, brown spots (lesions) develop on foliage.	Rarely damaging, primarily cosmetic, no management needed. See general discussion of leaf spots on Page 6.
	Ramorum blight also called sudden oak death *Phytophthora ramorum*	Large necrotic (brown) blotches on foliage. Shoot dieback. Blackening of leaf stems and succulent shoots. Defoliation. Most likely to occur during wet conditions.	**Not known to occur in Kansas but could become introduced.** Most likely to be introduced on nursery stock. Avoid purchasing and planting suspect material. Contact KSU Plant Disease Diagnostic Clinic to report suspect plants.
	Root rot *Phytophthora* spp.	Common in nurseries but less common in landscapes. Affected plants wilt and leaves drop. Roots and stems may develop a reddish-brown discoloration.	Inspect all nursery stock before purchasing. Avoid planting in sites with poor drainage. Improve drainage in problem areas. See discussion of wet soils on Page 3 and root rots on Page 9.
	Winter injury	Branch and twig dieback.	See general comments on winter injury on Page 2.
	Black vine weevil *Otiorhynchus sulcatus* (see Page 11)	Adults, which are active at night, feed on leaf margins creating small notches around the leaf edges. Heavy infestations may completely defoliate plants. Larvae feed on plant roots and may girdle plants at the crown resulting in wilting and possibly plant death (Figures 49 – 51).	Adult feeding primarily affects the aesthetic appearance of plants. The larva is the life stage that can cause substantial plant damage. As such, insecticide applications to the soil may be required to prevent larval damage.
Rose *Rosa*	Black spot *Diplocarpon rosae*	Leaves develop roughly circular, black spots with feathery margins. Multiple spots will cause yellowing of the leaf and defoliation. Most common in wet conditions. Can also infect canes (Figure 14).	Choose a variety with reduced susceptibility. Rake and remove (do not compost) fallen affected leaves. Avoid overhead irrigation and improve airflow to promote drying. Prune out infected canes. Fungicides may be beneficial in sites with chronic, severe disease. Contact your local extension office for information.

Host	Diseases and Environmental Stresses	Symptoms/Identification	Comments
Rose, cont.	Botrytis blight/ gray mold *Botrytis cinerea*	Spotting and browning of petals. Petals shed. Grayish brown fuzzy fungal growth may be present. Most common in wet, humid conditions. In very wet years may cause bud blight.	Primarily cosmetic. Disease development ceases during hot, dry weather. Improve air flow.
	Cane cankers Several fungi	Small spots or lesions form on canes, often at a pruning cut. These lesions may expand rapidly and kill the cane.	Prune out all cankered canes several inches below the margin of the discolored area. Maintain overall plant health with proper pruning, fertilization and irrigation.
	Environmental scorch	Leaf margins and/or entire leaves turn brown and dry (scorched) during dry, windy conditions (Figure 1).	Provide adequate water. Use mulches to help retain soil moisture. See general discussion of environmental scorch on Page 2.
	Leaf spot *Cercospora rosicola*	Leaves develop purple-brown lesions.	Rake up and remove infected leaves. See general discussion of leaf spots on Page 6.
	Crown gall *Agrobacterium tumefaciens*	Large woody galls develop, usually on root collar or roots (Figure 38). Galls reduce plant vigor and eventually can kill plant. Causal bacterium persists long term in soil at the site.	Avoid planting infected materials. Inspect before purchasing/planting. Remove and destroy entire infected plants. Do not simply prune out galls. Do not replant with a susceptible host. See further details in general discussion of crown gall on Page 8.
	Downy mildew *Peronospora sparsa*	Leaves develop irregular or angular spots that are brown, purple, or red. Severe defoliation can occur. In cool, humid (humidity greater than 85 percent) conditions fuzzy sporulation may be visible on the undersides of leaves. Rare in landscape due to typical hot, dry Kansas weather.	In nursery or greenhouse production use ventilation and irrigation practices that reduce humidity and leaf wetness. Avoid introducing infected plants to the greenhouse, nursery, or landscape. Remove and destroy affected leaves.
	Powdery mildew	White, powdery fungal growth develops on leaf surfaces.	Rarely damaging, primarily cosmetic, no management necessary. Improving airflow may reduce severity. See general discussion of powdery mildew on Page 7.

Host	Diseases and Environmental Stresses	Symptoms/Identification	Comments
Rose, cont.	Rose mosaic caused by several viruses, often in combination	Leaves develop a yellowing, mottling, variegation, or ringlike patterns (Figure 44). Diseased plants normally are not killed but they have reduced vigor and may be more prone to winterkill. Symptoms are most prominent on new growth in spring and may not be visible in late summer or early fall. The virus is spread by propagation practices.	There is no control for this disease once the plant is infected. Purchase virus-free plants. Do not purchase or plant roses with evidence of viral infection. Do not propagate from diseased plants. Remove and destroy affected plants. See discussion of viruses on Page 9.
	Rose rosette (once thought to be caused by a phytoplasma, new evidence has identified an emaravirus as the cause)	Very serious on multiflora rose (an invasive weed) but will attack all rose types. Diseased plants often have a red or purple cast and develop large witch's brooms of the canes. Excessive thorniness. Infected plants often die within 5 years. Spread by an eriophyid mite (Figures 45).	There is no control for this disease once the plant is infected. The disease can spread quickly in a planting. Promptly remove and destroy all diseased plants. See discussion of viruses on Page 9.
	Rust *Phragmidium* spp.	Yellow-orange spots develop on upper leaf surfaces (Figure 21a). Leaves develop powdery, orange pustules on the lower surfaces (Figure 21b). Pustules may turn black with development of another spore type in late summer/fall. Defoliation may occur and can be severe.	Remove infected leaves. Avoid overhead irrigation. If disease is chronic and severe, fungicides may be beneficial. See discussion of rusts on Page 7.
	Japanese beetle *Popillia japonica* (see Page 10)	Adults are metallic green in color with coppery-brown wing covers (Figure 48). White tufts of hair are present at the end of the abdomen. Feeding by adults causes leaves to appear lace-like or skeletonized.	Handpicking of adult beetles may be effective for situations associated with small plants and low infestations. However, contact insecticides may be required to prevent substantial damage to plants.
	Twospotted spider mite *Tetranychus urticae* (see Page 13)	Twospotted spider mites (Figure 73) feed on the leaf undersides causing leaves to appear light yellow (bleached) to bronze in color (Figure 74). Leaves may also be white or have yellow stippling. Heavily-infested leaves may turn brown and fall off plants.	A forceful water spray applied to the leaf underside will quickly remove all life stages of spider mites. Miticides may be used; however, they must be applied frequently enough and all plant parts must be thoroughly covered, especially leaf undersides, with the spray solution.

Host	Diseases and Environmental Stresses	Symptoms/Identification	Comments
Rose, cont.	Rose aphid *Macrosiphum rosae*	Aphids may be very noticeable feeding in large groups on leaves, stems, and developing buds (Figure 113). Feeding causes leaves to curl upward and deforms flower buds. Aphids produce honeydew (sticky liquid).	A forceful water spray applied to locations where aphids are feeding will quickly remove them. Contact and systemic insecticides may be effective in regulating aphid populations if applied early in the growing season; before aphid populations are extensive.
	Winter injury	Branch and twig dieback.	See general comments on winter injury on Page 2.
	Iron chlorosis	Yellowing of leaf tissue between veins; veins remain green.	Avoid planting susceptible species in high pH soils. In severe cases provide iron with injections. See general discussion of iron chlorosis on Page 4.
Russian olive *Elaeagnus angustifolia* ***Note:*** Russian olive can become invasive in pastures.	Verticillium wilt *Verticillium dahliae*	Wilting, yellowing, decline, dieback (Figure 31). Vascular discoloration (brown streaking) may be visible when viewing cross-section of cut branches or when bark is removed (Figure 32).	Maintain overall plant health with appropriate watering, fertilization, etc. Do not replant a susceptible species into a site with history of Verticillium wilt. See general discussion of Verticillium wilt on Page 8.
	Stem canker *Phomopsis, Tubercularia,* and *Botryosphaeria*	Oval to elongate dark sunken cankers on branches. Infected bark remains smooth but cracks may form at the margin of the canker. Fruiting bodies develop in the dead bark and appear as raised pustules. Branch dieback and tree death.	Remove and discard or destroy diseased branches. Cut branches at least 6 inches below any cankers when the wood is dry. Maintain overall plant health with proper pruning, fertilization and irrigation. See general discussion of cankers on Page 8.
	Leaf spot *Septoria argyraea*	Round to oval leaf spots with a gray center and dark margin. Fungal fruiting bodies (pycnidia) appear as small black dots in the center of the spot.	Rarely damaging, primarily cosmetic, no management needed. See general discussion of leaf spots on Page 6.

Host	Diseases and Environmental Stresses	Symptoms/Identification	Comments
Serviceberry *Amelanchier*	Fire blight *Erwinia amylovora*	Sudden browning and wilting of branch spurs (Figure 91) or new shoot growth. Tips of blighted shoots curl, giving appearance of a "shepherd's crook" (Figure 92). Inner bark tissue turns water soaked with red-to-black discoloration. Cankers form on affected branches. Favored by wet spring weather.	Prune out affected branches at least 12 inches below visible damage. Sanitize tools between cuts. See further discussion of fire blight under crabapple.
	Leaf spots various fungi	Round, brown spots (lesions) develop on foliage. Most common in wet years.	Rarely damaging, primarily cosmetic, no management needed. See general discussion of leaf spots on Page 6 for more information.
	Powdery mildew	White, powdery fungal growth develops on leaf surfaces.	Rarely damaging, primarily cosmetic, no management necessary. Improving airflow may reduce severity. See general discussion of powdery mildew on Page 7.
Spirea *Spirea*	Crown gall *Agrobacterium tumefaciens*	Large woody galls develop, usually on root collar or roots (Figure 38). Galls reduce plant vigor and eventually can kill plant. Causal bacterium persists long term in soil at the site.	Avoid planting infected materials. Inspect before purchasing/planting. Remove and destroy entire infected plants. Do not simply prune out galls. Do not replant with a susceptible host. See further details in general discussion of crown gall on Page 8.
	Iron chlorosis	Yellowing of leaf tissue between veins; veins remain green.	Avoid planting susceptible species in high pH soils. In severe cases provide iron with injections. See general discussion of iron chlorosis on Page 4.
	Leaf spot various fungi	Round, brown spots (lesions) develop on foliage. Leaf yellowing and minor shedding.	Rarely damaging, primarily cosmetic, no management needed. See general discussion of leaf spots on Page 6.
	Powdery mildew	White, powdery fungal growth develops on leaf surfaces.	Rarely damaging, primarily cosmetic, no management necessary. Improving airflow may reduce severity. See general discussion of powdery mildew on Page 7.

Host	Diseases and Environmental Stresses	Symptoms/Identification	Comments
Spirea, cont.	Spirea aphid *Aphis spiraecola*	Aphids congregate on terminal growth and may cause leaf curling and stunted plant growth. Aphids produce honeydew (sticky liquid) (Figure 61).	A forceful water spray applied to locations where aphids are feeding will quickly remove them. Contact and systemic insecticides may be effective in regulating aphid populations if applied early in the growing season; before aphid populations are extensive. See general discussion of aphids on Page 12.
Spruce *Picea* spp.	Canker *Leucostoma kunzei* also called *Cytospora kunzei*	Cankers on branches are covered with white patches of pitch. Small black fruiting bodies may be present in diseased bark. Scattered branch dieback.	Usually is found on drought-stressed or winter-injured trees. Remove infected branches but do not prune during wet weather. Maintain overall plant health with proper pruning, fertilization, and irrigation. See general discussion of cankers on Page 8.
	Environmental scorch/environmental decline	Very common. Needles turn brown to purple, sometimes including current year's growth. Needle drop and branch dieback.	Caused by stress from growing in less than ideal conditions. Spruce are not well adapted to Kansas growing conditions. Provide tree with adequate watering and fertilization. Plant in protected location. See general discussion of environmental scorch on Page 2.
	Needlecast *Rhizosphaera kalkoffi* and *Stigmina lautii*	Interior (1- and 2-year-old) needles on lower branches turn purplish-brown in summer and usually drop by late fall. Black spots in lines/rows may be visible on needles in late fall or early spring (Figure 15b, Figure 115). Starts in lower tree and works upward over several years (Figure 114). Most common in wet years. Most common in eastern half of Kansas.	Improve airflow by avoiding overcrowded plantings. For *Rhizosphaera*, application of fungicides in spring, when needles are half-elongated and again when needles are fully elongated, may reduce disease. No materials currently available for *Stigmina*.
	Bagworm *Thyridopteryx ephemeraeformis*	Caterpillars create small bags or cases covered with material from host plant. Feeding causes browning of needle tips. Young caterpillars are ⅛ to ¼ inch long whereas the mature caterpillar bags are 1 to 2 inches long (Figures 52 – 53).	Can cause substantial damage if not dealt with. Contact or stomach poison insecticides may be used to deal with extensive infestations. Removing female bags by hand in the winter may be effective in reducing caterpillar populations the following season. See Page 11.

Host	Diseases and Environmental Stresses	Symptoms/Identification	Comments
Spruce, cont.	Spruce spider mite *Oligonychus ununguis*	Feeding by mites causes needles to change color, turning mottled in appearance, and then yellow and eventually bronze. Damaged needles may fall off prematurely. Heavy infestations may cause branch dieback.	A forceful water spray will remove all life stages (eggs, larvae, nymphs, and adults). Miticides may be applied; however, thorough coverage of all plant parts is important. A dormant oil spray applied in winter may be effective in killing overwintering eggs located on the bark and needles. See Page 14.
Sumac *Rhus*	Fusarium wilt *Fusarium oxysporum* f. sp. *rhois*	Wilting, yellowing, decline, dieback. Vascular discoloration (brown streaking) may be visible when viewing cross-section of cut branches or when bark is removed.	Maintain overall plant health with appropriate watering, fertilization, etc.
	Verticillium wilt *Verticillium dahliae*	Wilting, yellowing, decline, dieback (Figure 31). Vascular discoloration (brown streaking) may be visible when viewing cross-section of cut branches or when bark is removed (Figure 32).	Maintain plant health with appropriate watering and fertilization. Do not replant a susceptible species into a site with history of Verticillium wilt. See general discussion of Verticillium wilt on Page 8.
Sweetgum *Liquidambar styraciflua*	Canker various fungi	Branch dieback. Tissue under bark is dead/brown.	Maintain overall plant health with proper pruning, fertilization, and irrigation. See general discussion of cankers on Page 8.
	Environmental scorch	Leaf margins and/or entire leaves turn brown and dry (scorched) during dry, windy conditions (Figure 1).	Provide adequate water. Use mulches to help retain soil moisture. See general discussion of environmental scorch on Page 2.
	Iron chlorosis	Yellowing of leaf tissue between veins; veins remain green (Figure 5).	Avoid planting susceptible species in high pH soils. In severe cases provide iron with injections. See general discussion of iron chlorosis on Page 4.
	Leaf spots various fungi	Round, brown spots (lesions) develop on foliage. Primarily in late summer during wet years.	Rarely damaging, primarily cosmetic, no management needed. See general discussion of leaf spots on Page 6.
	Bacterial wetwood several bacterial species	Liquid oozes from wounds and cracks and runs down bark, leaving discolored streaks on branches or trunk (Figure 42).	Rarely damaging, primarily cosmetic, management not necessary. See general discussion of wetwood on Page 9.

Host	Diseases and Environmental Stresses	Symptoms/Identification	Comments
Sycamore and London Plane *Platanus*	Anthracnose *Apiognomonia veneta* also called *Gnomonia plantani* or *Discula platani*	Brown irregular areas along veins. Young leaves turn brown and fall off. Twigs may be killed (Figure 17). Infection occurs in cool weather just as buds open. London Plane is less susceptible than Sycamore.	Rarely damaging, primarily cosmetic, no management needed. Trees usually produce new foliage and recover with the onset of warmer, drier summer weather. See general comments on anthracnose on Page 6.
	Powdery mildew	White, powdery fungal growth develops on leaf surfaces.	Rarely damaging, primarily cosmetic, no management necessary. Improving airflow may reduce severity. See general discussion of powdery mildew on Page 7.
	Environmental scorch	Leaf margins and/or entire leaves turn brown and dry (scorched) during dry, windy conditions (Figure 1).	Provide adequate water. Use mulches to help retain soil moisture. See general discussion of environmental scorch on Page 2.
	Bacterial wetwood Several bacterial species	Liquid oozes from wounds and cracks and runs down bark, leaving discolored streaks on branches or trunk (Figure 42).	Rarely damaging, primarily cosmetic, management not necessary. See general discussion of wetwood on Page 9.
	Sycamore lace bug *Corythucha ciliata* (see Page 12)	Damage appears as light-yellow mottling or stippling on the upper leaf surface. Black eggs and nymphs, and lacy-appearing adults may be present on leaf undersides (Figures 64 – 66).	In general, lace bugs will not severely damage plants although extensive populations may reduce aesthetic appearance. Contact insecticides may be used although thorough coverage of the leaf undersides is important. However, this may be impractical for large plants.
Viburnum *Viburnum*	Canker *Botryosphaeria*, others	Branch dieback. Wood under bark is brown/dry. Most common on stressed plants.	Maintain overall plant health with proper pruning, fertilization and irrigation. See general discussion of cankers on Page 8. If cankers develop, prune out and remove or destroy affected wood.
	Powdery mildew	White, powdery fungal growth develops on leaf surfaces.	Rarely damaging, primarily cosmetic, no management necessary. Improving airflow may reduce severity. See general discussion of powdery mildew on Page 7.

Host	Diseases and Environmental Stresses	Symptoms/Identification	Comments
Viburnum, cont.	Ramorum blight also called sudden oak death *Phytophthora ramorum*	Large necrotic (brown) blotches on foliage. Shoot dieback. Blackening of leaf stems and succulent shoots. Defoliation. Most likely to occur during wet conditions.	**Not known to occur in Kansas but could become introduced.** Most likely to be introduced on nursery stock. Avoid purchasing and planting suspect material. Contact KSU Plant Disease Diagnostic Clinic to report suspect plants.
Walnut *Juglans*	Anthracnose *Gnomonia leptostyla* also known as *Marsonina juglandis*	Irregular brown or black spots on leaflets, sometimes with yellow margins. Premature defoliation. Brown to black sunken spots on nut hulls.	Rarely damaging, primarily cosmetic, management not needed. See general comments on anthracnose on Page 6.
	Environmental scorch	Leaf margins and/or entire leaves turn brown and dry (scorched) during dry, windy conditions (Figure 1).	Provide adequate water. Use mulches to help retain soil moisture. See general discussion of environmental scorch on Page 2.
	Fusarium canker *Fusarium solani*	Branch dieback. Long, dark areas of dead tissue under bark.	Occurs primarily after harsh winters. See general discussion of cankers on Page 8.
	Powdery mildew	White, powdery fungal growth develops on leaf surfaces.	Rarely damaging, primarily cosmetic, no management necessary. Improving airflow may reduce severity. See general discussion of powdery mildew on Page 7.
	Thousand cankers disease *Geosmithia morbida*	Associated with walnut twig beetle (*Pityophthorus juglandis*) (Figure 78). Branch dieback, overall tree decline, small black cankers and beetle galleries visible under bark. Beetle exit holes are tiny but may be visible in bark. Exit holes are easier to see in younger branches with smoother bark.	**Not known to occur in Kansas but spread into Kansas is possible.** Contact your local extension office for information. See general discussion of cankers on Page 8.
	Fall webworm *Hyphantria cunea*	Create large nests or webbing in tree branches. Caterpillars, which are yellow-green to brown in color with black spots, remain in the nests feeding (Figures 56 – 58).	Prune out localized nests or webbing and dispose of immediately. Use a rake to disrupt the nest, which will allow birds to feed on the caterpillars. See Page 11.

Host	Diseases and Environmental Stresses	Symptoms/Identification	Comments
Willow *(Salix)* – see Poplar			
Yew *Taxus*	Root decline (wet soils)	Branch dieback, plant decline (Figure 116).	Avoid planting into poorly drained soils. See discussion of wet soils on Page 3.
Yew, cont.	Root rot *Phytophthora* spp.	Branch dieback, plant decline. Most common in sites with poor drainage.	Avoid planting into poorly drained soils. See discussion of wet soils on Page 3 and root rots on Page 9.
	Environmental scorch	Browning and drying of foliage and branch tips during dry conditions.	Provide adequate water. See discussion of environmental scorch and winter desiccation on Page 2.
	Winter desiccation	Browning and drying of foliage during dry, windy winter conditions.	Provide adequate water. See discussion of environmental scorch and winter desiccation on Page 2.
	Winter injury	Branch dieback.	Prune out damaged branches to improve appearance. See discussion of winter injury on Page 2.
	Black vine weevil *Otiorhynchus sulcatus*	Adults, which are active at night, feed on leaf margins creating small notches around the leaf edges. Heavy infestations may completely defoliate plants. Larvae feed on plant roots and may girdle plants at the crown resulting in wilting and possibly plant death (Figures 49 – 51).	Adult feeding primarily affects the aesthetic appearance of plants. The larva is the life stage that can cause substantial plant damage. As such, insecticide applications to the soil may be required to prevent larval damage. See Page 11.
	Bagworm *Thyridopteryx ephemeraeformis*	Caterpillars create small bags or cases covered with material from host plant. Feeding causes browning of growth tips. Young caterpillars are ⅛ to ¼ inch long whereas the mature caterpillar bags are 1 to 2 inches long (Figures 52 – 53).	Can cause substantial damage if not dealt with. Contact or stomach poison insecticides may be used to deal with extensive infestations. Removing female bags by hand in the winter may be effective in reducing caterpillar populations the following season. See Page 11.
Zelkova *Zelkova*	Environmental scorch	Leaf margins and/or entire leaves turn brown and dry (scorched) during dry, windy conditions (Figure 1).	Provide adequate water. Use mulches to help retain soil moisture. See general discussion of environmental scorch on Page 2.

Figure 61. *Aphids.*

Figure 62. *Adult leafhopper.*

Figure 63. *Leafhopper feeding damage.*

Figure 64. *Lace bug adult.*

Figure 65. *Lace bug nymphs.*

Figure 66. *Lace bug feeding damage on oak leaf.*

Figure 67. *Obscure scale.*

Figure 68. *Pine tortoise scale.*

Figure 69. *Oak kermes scale.*

Figure 70. *European elm scale.*

Figure 71. *Euonymus scale.*

Figure 72. *Lecanium scales on bald cypress.*

Figure 73. *Twospotted spider mite adult.*

Figure 74. *Twospotted spider mite feeding damage.*

Figure 75. *Cottonwood borer adult.*

Figure 76. *Cottonwood borer larva.*

Figure 77. *Pine sawyer beetle adult.*

Figure 78. *Walnut twig beetle adult.*

Figure 79. *Emerald ash borer adult.*

Figure 80. *Emerald ash borer adult emergence hole.*

Figure 81. *Emerald ash borer larvae.*

Figure 82. *Asian longhorned beetle adult.*

Figure 83. *Lilac/ash borer adult.*

Figure 84. *Lilac/ash borer larva.*

Figure 85. *Lilac/ash borer pupae.*

Figure 86. *Oak bullet gall.*

Figure 87. *Hackberry nipple gall maker.*

Figure 88. *Mushrooms and conks are indicators of decay. Shown here: ash heart rot caused by Perenniporia fraxinophila.*

Figure 89. *Black knot of cherry and other stone fruit causes black swellings on branches.*

Figure 90. *Peach leaf curl causes distortions and discoloration.*

Figure 91. *Branch spur killed by fire blight.*

Figure 92. *Fire blight causes a "shepherd's crook" in terminal shoots.*

Figure 93. *Elm black spot.*

Figure 94. *Phomopsis canker on forsythia.*

Figure 95. *Mimosa webworm.*

Figure 96. *Honeysuckle witches-broom aphid.*

Figure 97. *Bacterial leaf spot of hydrangea.*

Figure 98. *Kabatina tip blight on juniper.*

Figure 99. *Kabatina tip blight on juniper – lesion with fungal fruiting structures.*

Figure 100. *Phomopsis tip blight on juniper.*

Figure 101. *Phomopsis tip blight on juniper – lesion with fungal fruiting structures.*

Figure 102. *Cercospora needle blight can cause needle drop.*

Figure 103. *Tar spot of maple.*

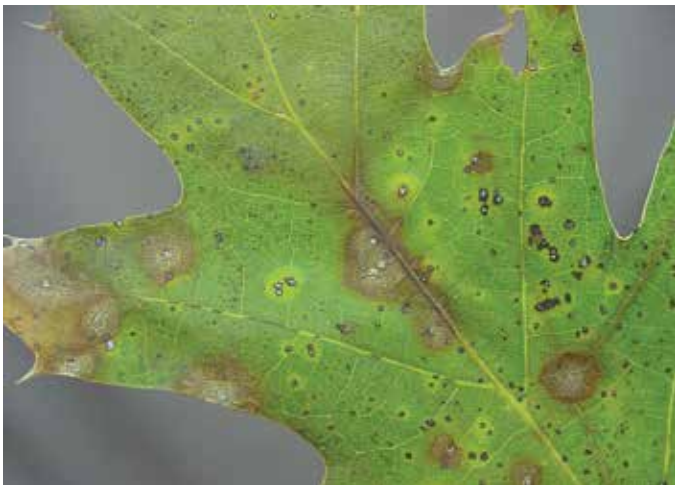

Figure 104. *Leaf spot of oak caused by Tubakia.*

Figure 105. *Oak wilt causes dark streaking in the vascular tissue.*

Figure 106. *Partial leaf scorch caused by oak wilt. Can be confused with environmental scorch.*

Figure 107. *Oak anthracnose.*

Figure 108. *Oak anthracnose.*

Figure 109. *Pine tip blight stunts needles and shoots.*

Figure 110. *Pine tip blight fungal fruiting structures on cones.*

Figure 111. *Dothistroma needle blight causes shedding of internal needles.*

Figure 112. *Redbud leaffolder.*

Figure 113. *Rose aphids.*

Figure 114. *Rhizosphaera needle cast causes shedding of lower, interior needles.*

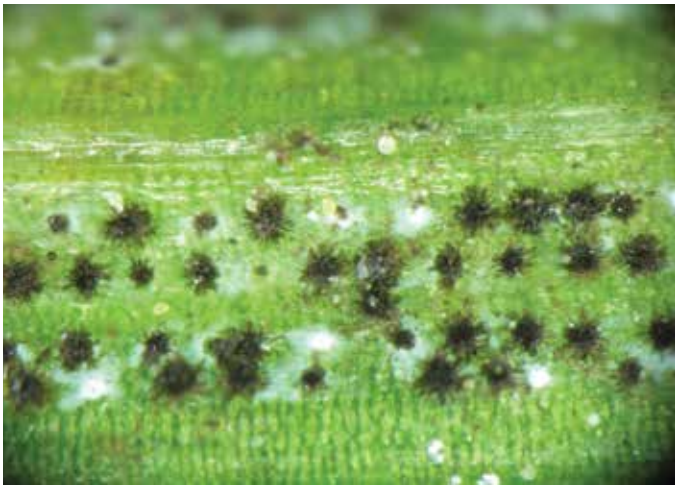

Figure 115. *Fruiting structures of Stigmina needle cast on spruce (compare to 15b).*

Figure 116. *Wet soil causes decline and dieback in yew.*

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MF3132 February 2014