Disease Management Guide for Connecticut Arborists 2015-2016

Prepared by

Dr. Sharon M. Douglas
Emeritus Plant Pathologist

Department of Plant Pathology and Ecology
The Connecticut Agricultural Experiment Station
New Haven, CT

I would also like to thank and acknowledge many Connecticut arborists for suggestions and comments that have helped to make each edition of this guide a more useful reference.

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Department of Plant Pathology and Ecology
The Connecticut Agricultural Experiment Station
123 Huntington Street (Zip 06511)
P. O. Box 1106
New Haven, CT 06504

Phone: 203.974.8601 or 203.974.8496
Fax: 203.974.8502
Email: Sharon.Douglas@ct.gov

CAES Website: www.ct.gov/caes

The pesticide suggestions included in this publication are provided only as a guide and are not all-inclusive. Although this guide contained up-to-date product information at the time of printing, frequent label and product registration changes may render some of the suggestions inappropriate by the time the guide is used. This publication makes no claims regarding the efficacy of the pesticides and the author assumes no liability resulting from the use of the strategies for disease management included in this guide.

This guide is not intended as a substitute for the pesticide label. Read and understand the label thoroughly before applying any pesticide.

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INTRODUCTION TO USE OF THE DISEASE MANAGEMENT GUIDE

The goal of this updated edition of the ***Disease Management Guide for Connecticut Arborists 2015-2016*** is to help arborists identify and manage current disease problems on common woody ornamentals in Connecticut. This guide provides a *Plant Health Management* approach that emphasizes plant health as a means to minimize or manage the impact of diseases. Part of this approach involves recognizing and identifying key diseases of specific hosts. This guide includes key biotic problems as well as problems associated with abiotic factors, since the impact of the weather extremes of the past few years on tree health have had increased importance in the Connecticut landscape. This publication is not all-inclusive, but highlights the ***current*** problems on selected common woody ornamentals in the landscape.

Accurate diagnosis of tree health problems is fundamental to disease management. It is necessary for keeping records about the occurrence and severity of a particular problem on a specific host, a key component of any management program. Regardless of the abiotic or biotic nature of a problem, knowing what happened the previous year is helpful, since it allows one to anticipate potential problems for the upcoming season. In the case of biotic problems, information about the amounts and sources of overwintering inoculum is helpful. However, even armed with this information, weather still plays a critical role in determining both the incidence and severity of disease each year. Temperature, rainfall, and relative humidity can influence the development of the disease agent, the host plant, or both. As a consequence, programs for disease management must be adjusted every year to take the prevailing environmental conditions into account. This is very important because, while certain diseases occur every year, there are other diseases that pose threats or occur when certain weather conditions prevail or if allowed to build up from year to year.

This guide consists of three main parts: a **Disease Management Guide,** a **Disease Management Calendar,** and a section of compiled **Fact Sheets**. The **Disease Management Guide** lists woody ornamentals by genus, common name, disease, pathogen/cause, diagnostic symptoms, management strategies, and materials (pesticides) registered for use. Many biofungicides can be combined with traditional (chemical) fungicides to produce synergistic effects. The list of fungicides in this guide is not all-inclusive, but serves as a reference for selecting appropriate materials. It is the responsibility of the pesticide user to follow the label and select products that are registered for use on specific crops, since labels vary with regard to hosts and diseases. It is also critical to use fungicides intelligently to prevent pathogens from developing resistance to particular fungicides. For example, continued use of myclobutanil can result in pathogens that develop resistance to this fungicide. Therefore, it is important to rotate myclobutanil with a fungicide with a different mode of action such as thiophanate methyl. Failure to adequately control diseases can be attributed to pathogens that have developed resistance from repeated use of products with similar modes of action.

The page references listed after each disease and/or causal agent refer to *Diseases of Trees and Shrubs, 2nd Edition* by W. A. Sinclair and H. H. Lyons. A complete citation for the newest edition of this important reference can be found in the list of references at the end of this guide. In the typical landscape, disease management is especially difficult since arborists must deal with many plant species, each of which has different and often unique plant health problems that cannot all be handled the same way. Because of this diversity, it is important to accurately identify and to know the relative importance of the disease in order to act with appropriate and timely management strategies (including use of culture, sanitation, resistance, and pesticides). Where applicable, management strategies and timing of pesticide applications are based on the phenology of the host. The descriptions of diagnostic symptoms included in this guide are designed to help in disease identification. For example, some diseases such as leaf spots and powdery mildews are more aesthetic than life-threatening and are often not serious enough to warrant chemical control. On the other hand, diseases such as fungal root rots can seriously debilitate and eventually kill individuals or entire plantings if left unchecked.

The second part of this guide is the **Disease Management Calendar,** which emphasizes "action periods" for implementing management strategies for specific diseases. The calendar year is divided into four action periods (dormant, budbreak, summer, and autumn) during which attention is focused on specific diseases and management practices important during that time of year. The calendar lists woody ornamentals by genus, common name, diseases, and control techniques.

The third part of this guide is a section of CAES **Fact Sheets**, which is a compilation of fact sheets for many of the common diseases covered in the **Disease Management Guide**. These provide more detailed information about the biology, spread, and management of specific diseases. The fact sheets can be photocopied for distribution to clients. All fact sheets (including newest revisions) can be found on the Experiment Station website: www.ct.gov/caes/pdio.

AN INTRODUCTION TO TREE HEALTH PROBLEMS

Historical Impact of Tree Health Problems

Trees and woody ornamentals in landscapes, woodlots, and forests are subject to a wide variety of problems that threaten their health. These problems can affect the aesthetics of the tree or can pose more serious consequences, such as disfigurement, economic loss due to reductions in yield and quality, and tree death. Diseases have also changed the composition of the forest and landscape. Until the early 1900's, the American chestnut was one of the most dominant and important hardwood tree species in the forests of the eastern United States. It was prized for its commercial value as a source of lumber, pulpwood, poles, tannins, railroad ties, and edible nuts. With the introduction of the fungus *Cryphonectria parasitica*, a species that was not native to the U.S., chestnut trees became infected with the chestnut blight fungus and the tree was almost completely eliminated from the forest. Today, sprouts continue to grow from old stumps, although they usually succumb to disease over time.

Dutch Elm Disease is another example of a disease that changed our city and town streets and greens. The fungus, *Ophiostoma ulmi*, along with one of the insects that transmits it, were introduced to the U.S. on logs imported from Europe. The American elm (*Ulmus americana)* was highly susceptible to these exotic pests and quickly succumbed to infection. Since many of the elm trees were planted in rows along city streets and parks, the fungus easily spread from tree to tree through root grafts and feeding activities of the beetle.

Because of the diversity of tree health problems and causal factors, it is important to learn to recognize them, understand what causes them, and why and when they occur. It is also helpful to understand their importance or relative impact. This information is helpful in order to prevent the problems from occurring or, if they do occur, to properly manage them.

What is Disease?

Plant disease can be defined in many ways, but one of the simplest definitions describes disease as any condition in a plant caused by living or nonliving agents that interferes with its normal growth and development. Diseases or plant health problems can impact plants in many ways, since all parts of a plant can be affected including flowers, leaves, fruits, seeds, stems, branches, growing tips, and roots.

Many different factors can cause plant health problems. These factors can be divided into two groups based on whether they are living or nonliving. Nonliving disease agents, often called abiotic agents, include factors such as environmental stress or cultural care. Living disease agents, called biotic agents or plant pathogens, include microorganisms such as fungi and bacteria. Both abiotic and biotic agents will be described in greater detail in the section "Types of Disease Agents."

How Does Disease Occur?

In order for disease to occur, three factors must be present. Because of this, disease is often pictured as a triangle having three equal sides. Each side of the triangle is necessary in order for disease to occur. One side of the triangle represents the host plant, the second side represents the causal agent or causal factor, and the third side represents the environmental conditions that are necessary in order for the other two sides to interact (Figure 1). When one or more sides of the triangle are missing, the triangle collapses and disease will not occur (Figure 2). For example, scab of crabapple is a very common disease in the Connecticut landscape. The "disease triangle" for this disease consists of the host plant, a susceptible variety of crabapple; the causal factor, the fungus *Venturia inaequalis*; and the proper environment, typically a cool, wet spring during which the young, emerging leaves stay wet for extended periods of time. When all three of these factors are present, scab will develop. If one component is missing, perhaps the spring weather is hot and dry and not favorable for disease development, disease will not occur since one side of the triangle is not present and the triangle collapses. Similarly, if you select a resistant variety of crabapple rather than a susceptible one, disease will not occur since that side of the triangle is missing and the triangle collapses (Figure 2)

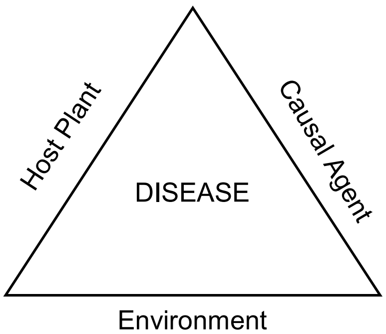

Figure 1. The Disease Triangle: All components are present and disease occurs.

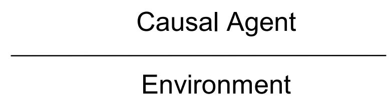

Figure 2. The Disease Triangle: One component is missing (Host Plant), so disease does not occur.

Types of Disease Agents

As previously mentioned, the two main categories of agents capable of causing plant disease are abiotic (nonliving) and biotic (living) factors. In natural settings, it is not uncommon for plants to be affected by both abiotic and biotic problems and it is often difficult to determine which came first. However, in many cases, plants that are initially stressed by abiotic factors will be weakened and therefore predisposed to biotic problems. For example, rhododendrons whose roots have been weakened by drought stress are more susceptible to the fungal root rot caused by *Armillaria* than their healthy counterparts.

Biotic Agents

Unlike abiotic agents, biotic agents are able to spread from plant to plant. This is an important attribute since the number of diseased plants can increase over time as a direct result of the growth, multiplication, and movement of the causal agent.

Fungi

The majority of plant diseases are caused by fungi. There are well over 100,000 different species of fungi and only a surprisingly small portion of them are capable of causing plant diseases. Fungi are similar to plants, but lack chlorophyll and the conductive or vascular tissues that are found in ferns and seed plants. Fungi are small (usually microscopic) organisms that consist of a mass of filaments or threadlike strands called hyphae. The primary means of reproduction and spread of fungi is by spores. Many fungi produce more than one type of spore during their life span and this often influences how diseases are spread.

The primary way that fungi infect plants is through direct penetration of tissues, although they also infect through natural openings such as stomates, hydathodes, and lenticels, or through wounds. In most cases, fungi require free water on plant surfaces in order to infect. Because of this environmental criterion, fungal diseases are frequently more common after periods of wet weather or when overhead irrigation is used. Fungi are primarily spread by wind, splashing water (from rain or irrigation), insects, and through cultural practices (e.g., on pruning shears, on pots, or in contaminated soil).

Bacteria

Bacteria are very different from fungi and are single-celled microorganisms that do not have an organized nucleus. As with fungi, only a small percentage of bacteria found in nature are capable of invading living plants and causing plant disease. Bacteria have cell walls and most plant-pathogenic bacteria are rod-shaped. Bacteria reproduce primarily by cell division. This can occur in a short period of time and their initial presence or growth within a plant is usually not visible.

Unlike fungi, bacteria generally cannot invade plant tissues that are intact and healthy. As a consequence, most infections occur through wounds. Bacteria also infect through wounds made by insects during their feeding activities and through natural openings in a plant such as nectaries or stomates. Bacteria are spread from plant to plant by splashing water (from rain or irrigation), by insects, and through a variety of cultural practices (e.g., as contaminants on pruning shears, in plant or soil debris in pots). Bacteria can also be transmitted by seeds from infected plants.

Phytoplasmas

Phytoplasmas are a relatively new type of disease agent that are closely related to bacteria, but lack a rigid cell wall. These organisms used to be called mycoplasma-like organisms or MLO's. As with bacteria, phytoplasmas have no organized nucleus and are microscopic and unicellular. They can be irregular and amoeba-like or spiral in shape. Phytoplasmas are tissue-specific and only live in the phloem or the nutrient-transport system of their plant hosts. Most phytoplasmas are incapable of living outside of their plant host or insect vectors.

Since phytoplasmas cannot survive as free-living microorganisms, they are incapable of infecting plants without "outside" assistance from insect vectors or by mechanical means of transmission. As a consequence, the primary way that phytoplasmas are spread is by phloem-feeding insects such as leafhoppers. Phytoplasmas can also be spread mechanically by grafting infected plant parts onto healthy plants.

Viruses and Viroids

Viruses are unique plant pathogens since they consist of nucleic acid and a protein coat and have no cellular structures. Additionally, viruses are unable to replicate or reproduce without the aid of the components of the plant host cell. Viroids are even more simplistic than viruses, since they lack a protein coat and consist only of nucleic acid.

Because of the nature of these disease agents, wounds are necessary in order for viruses and viroids to infect. Therefore, the primary means of spread is through the feeding activities of a number of insects, predominantly aphids, whiteflies, and leafhoppers. Viruses can also be spread by nematodes and in infected pollen. Human activities are also very important for spread of these disease agents. Included among these are grafting and mechanical transmission associated with the handling of infected plant material.

Nematodes

Nematodes are tiny, translucent roundworms, oftentimes just barely visible to the naked eye. As with fungi and bacteria, only a small portion of nematodes found in nature are parasitic to plants. Most nematodes have three life stages: egg, larva, and adult. The latter two stages are most damaging to plants. Plant-parasitic nematodes are obligate pathogens and have developed specialized structures called stylets, which allow them to pierce plant cells and extract cell contents.

Nematodes can infect plants through direct penetration. This usually occurs at the tip of a root. They also infect through wounds, through natural openings, and through the activities of certain insects that serve as vectors. Nematodes are also spread by infected plant material and by contaminated soil and plant debris.

Parasitic Flowering Plants

While these pathogens are not as common in Connecticut as in other regions of the country, they can cause damage to plants. Damage associated with most parasitic plants is more prevalent for herbaceous and crop plants, although they can be occasional problems for trees. There are two types of parasitic plants: stem and root parasites. Root parasites include beech drops and broomrapes. Stem parasites include leafy and dwarf mistletoes and dodder, and are generally considered to be more damaging to trees than root parasites.

Abiotic Agents

Plant health problems attributed to abiotic agents can also be referred to as disorders rather than diseases. Both terms are used to describe the same types of abnormalities in a plant although disorder usually implies the causal factor is nonliving whereas disease usually implies the causal factor is a living agent. Abiotic disease agents can be categorized as being cultural or environmental. These types of agents are often overlooked as probable causes of plant health problems because they are very difficult to identify since they cannot be cultured or viewed microscopically. As a consequence, the ability to pinpoint the causal factor requires close review and examination of the cultural and environmental history of the plant in question.

Environmental Factors

Many types of environmental factors cause plant diseases. Among these are unusual precipitation patterns resulting in drought or waterlogged soils, limited snow cover, excessive winds, lightning, hail, late spring or early autumn frosts, and extreme temperature fluctuations, especially during the winter. Air pollution is another important factor. Among the pollutants encountered in Connecticut are ozone, hydrogen fluoride, sulfur dioxide, ethylene, and peroxyacyl nitrate. Some of these compounds are more problematic in glasshouses and others primarily occur outdoors.

Environmental disease agents result in a wide variety of symptoms. For example, drought or dry soil conditions result in root damage and death. Non-woody feeder roots, usually located in the top 15 inches of soil, are particularly sensitive and are the first ones affected. Without moisture, these roots shrivel and die. When these roots become nonfunctional, a water deficit develops since the roots cannot provide water to the top of the plant. Symptoms of drought vary with the plant species and the severity of the water deficit but are often not evident until sometime after the event has occurred--even as much as one or two years later. Symptoms include loss of turgor in needles and leaves, drooping, wilting, yellowing, premature leaf or needle drop, bark cracks, and twig and branch dieback. Leaves on deciduous trees often develop marginal scorch and interveinal necrosis whereas needles on evergreens turn brown. Drought-stressed trees and shrubs can also exhibit general thinning of the canopy, poor growth, and stunting. In extreme cases, drought can result in plant death.

Cultural Factors

Cultural factors associated with plant health problems are quite diverse. Among the common factors are site and soil attributes (e.g., pH, organic matter, drainage, soil type), planting practices (e.g., preparation of the rootball and planting hole, planting too deep or too shallow), plant hardiness, construction activities resulting in soil compaction or severing of roots, and mechanical injuries from lawn mowers and string trimmers. Other types of problems result from incorrect or improperly timed pruning, incorrect mulching, fertilizing practices (e.g., incorrect timing, inappropriate applications resulting in toxicities or deficiencies), and watering practices (e.g., too late in the day, too much or too little, and frequent, shallow watering).

Another type of cultural agent that can result in plant damage and death involves chemicals. Included in this category are de-icing salts and misapplied pesticides, particularly herbicides. For example, misapplied herbicides can result in damage that varies with the particular compound and plant species. Symptoms can develop several days to weeks after exposure or, in some cases, not until the following spring. Symptoms include chlorosis, necrotic spotting, marginal scorch, twisting, growth abnormalities, leaf/needle drop, dieback, general decline, and plant death.

As with environmental factors, cultural factors can affect plant health in many ways and result in a wide range of symptoms. For example, when mulches are applied too close to the base of a plant and too thick, they can result in root and crown rots and asphyxiation of roots, respectively. This can cause plant decline and death.

For more detailed information on many of these abiotic disease agents, please refer to the *Fact Sheets* portion of this guide or the CAES website (http://www.ct.gov/caes/pdio).

Disease Cycles

Disease cycles help in understanding how the components of the disease triangle fit together in a dynamic framework. They help to describe when infections occur, how disease agents are carried over the winter, and how to determine when a fungicide application would be most effective. Knowledge of the type of cycle for a particular disease will assist in determining the strategies for managing that disease.

There are several types of disease cycles but the three most prevalent ones for diseases of ornamental and shade trees are simple, complex, and multiple host cycles.

Simple Cycle

A simple disease cycle is characteristic of diseases that have one infection period per year. Because there is only one infection period per year, there is only one opportunity for control using fungicides. An example of a disease with a simple cycle is oak leaf blister (Figure 3). In this disease, there is only one spore stage of the fungus that is capable of infecting newly developing leaves. The fungus overwinters in buds and bud scales. As temperatures increase in spring, the fungus produces ascospores that infect buds as they begin to swell. Symptoms develop on infected leaves during the summer but no new infections can occur. Since there is only one infection period per year, the only opportunity to control the disease would be fungicide applications targeted to inhibit primary infections during bud swell (note dotted line intersecting the disease cycle). Although fungicide applications at this time are effective, this disease is not serious enough to warrant chemical controls in most situations.

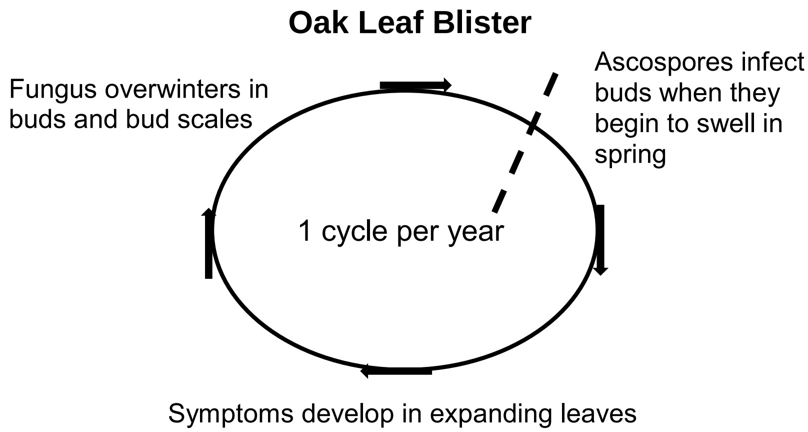

Figure 3. Simple disease cycle of oak leaf blister.

Complex Cycle
A complex cycle is characteristic of diseases that have multiple cycles each year. These types of diseases typically have two cycles, a primary cycle and a repeating, secondary cycle. Since secondary cycles are embedded in primary cycles, they are dependent upon primary cycles in order to exist. If the primary cycle is stopped, the secondary cycle can't begin. An example of a disease with a complex cycle is scab on crabapple (Figure 4). Because there are two cycles, there are two opportunities for disease control. In the case of scab, there are two types of spores produced by the causal fungus. The spores responsible for the primary cycle overwinter in fallen leaves. In spring, spores are produced in the fallen leaves that initiate the primary cycle of disease as these spores infect newly emerging leaves, flowers, and young fruit.

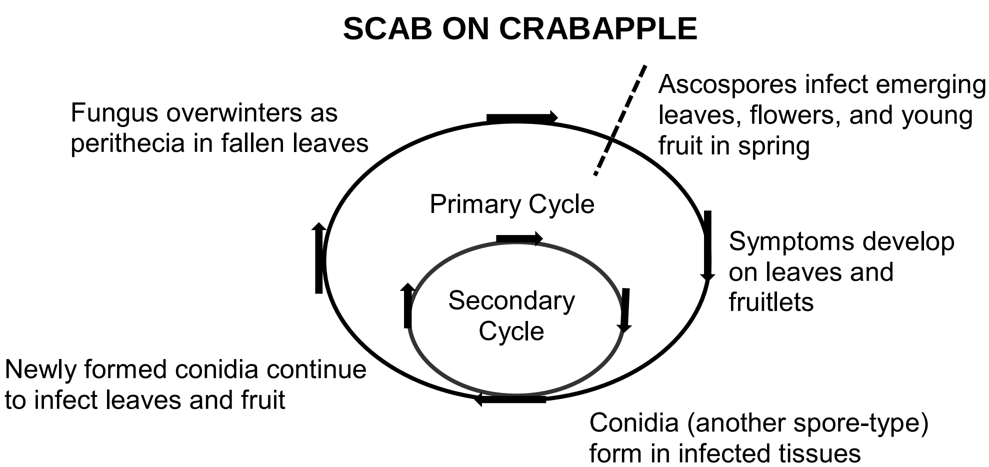

Figure 4. Complex disease cycle of scab on crabapple.

The primary cycle is completed when symptoms develop on leaves and fruitlets. Another type of spore is produced in the infected tissues, which in turn initiate secondary cycles. Multiple secondary cycles can occur as new lesions occur and more spores are produced to initiate new secondary infections. The first opportunity for controlling this disease would be fungicide applications aimed at stopping the primary cycle. These would be applied to protect newly emerging tissues in spring (note dotted line intersecting the primary cycle). This is the most effective and important way to control this disease with fungicides since breaking the primary cycle eliminates the existence of the secondary cycle. In cases where the primary cycle is not properly controlled, the second opportunity to stop this disease is to target additional sprays to protect tissues from infection by the spores initiating the secondary cycle. This type of control is much more difficult than controlling primary infections since repeating cycles can occur.

Multiple Host Cycle

A multiple host cycle is characteristic of diseases caused by pathogens that require more than one host (and in some cases require more than one year) to complete their life cycles. An example of a disease with a multiple host cycle is cedar-apple rust (Figure 5). This pathogen requires two distinctly different hosts: primary hosts are apple and crabapple and secondary or alternate hosts are junipers, including eastern red cedar. The most effective way to manage this disease is to separate the two types of hosts. Imagine breaking the circle into two pieces right down the middle and separating the crabapple and juniper hosts. Unfortunately this is not feasible in most landscape situations since the two hosts need to be separated by one mile in order to be effective. The most commonly used strategy to manage this disease in the landscape is to prevent infections from occurring by protecting tissues with fungicides. The fungus overwinters in galls on the juniper hosts. In spring, gelatinous, orange telial horns containing spores develop on overwintering galls. These spores produce another spore that is only able to infect apple or crabapple hosts and initiate infections as the newly emerging leaves develop. Reddish to orange spots develop on infected leaves in which other types of spores are produced. These spores can only infect juniper and infections occur as the spores are wind- or rain-driven to the junipers. The most effective way to break this cycle is to apply fungicides to protect the newly emerging crabapple leaves from infection (note dotted line intersecting the crabapple portion of the cycle). If crabapple infections don’t occur, the disease is stopped since the spores that infect junipers are not produced on those crabapple hosts.

CEDAR-APPLE RUST

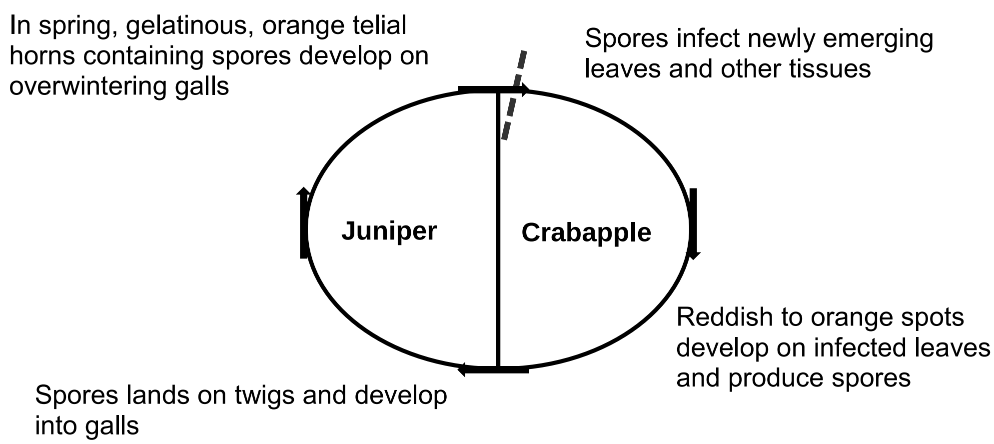

Figure 5. Multiple host cycle of cedar-apple rust.

Types of Plant Health Problems

A significant factor that influences the ability to manage plant health problems lies with the ability to recognize a problem when it occurs. One of the most important ways to identify a problem is by the symptoms that are produced by the affected plant. A symptom is defined as the response of a plant to the presence of a disease agent, regardless of whether it is nonliving (abiotic) or living (biotic). Symptoms are the external and internal reactions of a plant as a result of disease. The presence of a symptom on a plant distinguishes the diseased plant from its healthy counterparts. Plants can exhibit a variety of symptoms, some of which are associated with a specific causal factor, but more commonly, can be associated with many different factors. Symptoms can also occur on many different parts of a plant. Additionally, it is not uncommon for a diseased plant to exhibit more than one type of symptom. For example, the initial symptoms of dogwood anthracnose appear as distinct spots approximately ¼-½ inch in diameter with dark purple margins. These spots are usually scattered over the surface of the leaf. However, when the number of spots increases, they coalesce and the leaves develop a blighted appearance as they turn completely brown and shrivel.

Some of the common symptoms that we encounter on diseased plants are listed and defined in this section. These terms provide the vocabulary or terminology to describe what we see when a plant does not appear healthy or normal.

Examples of Common Symptoms of Plant Disease:

***Blight*:** rapid yellowing, browning, collapse, and death of leaves, shoots, and stems, especially young, growing tissues; usually occurs very quickly and involves a major portion of a tree.

***Canker*:** dead area on twigs, stems, or main trunk; can be sunken, swollen, or discolored and are usually distinguished from adjacent healthy tissues by color.

***Chlorosis*:** yellowing of normally green tissues due to lack of chlorophyll.

***Dieback*:** large portion of dead tissue in a tree; death of the tips of leaves, shoots, and stems; failure of branches to develop, especially in the spring.

***Gall*:** swelling or abnormal growth of plant tissues; can develop on leaves, stems, and roots; may be induced by insects, fungi, bacteria, or nematodes.

***Gummosis*:** exudation of sap or gum from wounds, cracks, or other openings in the bark.

***Leaf blotch*:** dead areas of tissue on foliage; irregular in shape and larger than leaf spots.

***Leaf spot*:** spots of dead tissue on the foliage; the size, shape, and color may vary with causal agent and host; usually limited to a relatively small portion of the leaf surface.

***Necrosis*:** death of plant cells or tissues; affected tissues are usually brown; necrotic = dead.

***Stunting*:** reduced plant growth; failure of plant parts to grow to full size; often used to describe an entire plant.

***Scorch*:** browning and death of indefinite areas of tissue along the leaf margins and/or between veins.

***Vascular discoloration*:** streaking or darkening of vascular tissues.

***Wilt*:** loss of turgor or drooping of leaves, shoots, or the entire tree due to apparent lack of water.

***Witches'-broom*:** abnormal proliferation of shoots from the same point on a plant resulting in a bushy, broom-like appearance.

Strategies for Managing Plant Health Problems

Regardless of the plant host or particular type of disease that you encounter, the concepts of disease prevention and management are fundamentally the same. Management of plant diseases involves a two-step process that first requires accurate diagnosis and assessment of the severity of the problem. This is followed by implementing strategies to minimize the impact of the disease.

1. Disease Diagnosis:

The first step in disease management is knowing what you're trying to control--is it a disease caused by a fungus or is it associated with the weather, the site, or your cultural care? Accurate diagnosis is very important since it determines two things: the need for control and the type of control. Some plant diseases are merely aesthetic and, under normal circumstances, don't require control measures. On the other hand, there are diseases that can be fatal if left uncontrolled. For example, tar spot of maple is usually not serious enough to require control measures even though it can result in premature defoliation. In contrast, Phytophthora root rot of rhododendron is a disease that interferes with water uptake and can seriously debilitate and eventually kill the plant if left unchecked.

Another part of diagnosis involves assessing the severity of the problem. This assessment is made by gathering information about the nature of the problem: is it a foliar or a root problem, is it localized to one part of the plant or is it systemic? It is also helpful to determine the level of the disease: how many plants are involved or how long have they been symptomatic?

Disease diagnosis based solely on symptoms can sometimes be misleading and can lead to improper, ineffective controls. In circumstances where different causal agents incite the same or similar symptoms on a host plant, accurate diagnosis requires identification of the causal agent. Since most biotic agents are microscopic, accurate identification is not possible without the necessary equipment. In these cases, samples may be submitted to the Plant Disease Information Office (PDIO) of the Experiment Station for diagnosis. Diagnosis can involve light microscopy and histochemical staining, isolation on artificial media, soil extraction, electron microscopy, studies of host range, and indicator plants. The PDIO also utilizes serological tests and a variety of other procedures as necessary. Information about the PDIO and about how to prepare and submit samples can be found in this ***Disease Management Guide*** or can be obtained by calling the PDIO or accessing the CAES website (www.ct.gov/caes/pdio).

2. Management Options:

A common misconception to disease control is that chemical sprays, dusts, and soil drenches are the only effective means of reducing the effects of plant disease. However, chemical control is only one component of a multifaceted approach that includes culture, sanitation, resistance, and biological and chemical components.

It is important to remember the goal of plant health management--it is not focused on completely eliminate diseases, but managing them so they remain at acceptable levels.

Culture: A key opportunity for disease management focuses attention on cultural manipulations that help to minimize conditions favorable for disease development. These include numerous methods that modify the plant's growing conditions in order to optimize growth and vigor.

a. Plant and Site Selection

- *Hardiness*- often an overlooked aspect of disease prevention; most of Connecticut is in USDA Zone 6 (some Zone 5); this is an important factor for consideration when trying new species;
- *Plant Requirements vs. Site Characteristics*- it is important to match the conditions required by a particular plant with the attributes of the intended site as closely as possible; special attention should be given to soil type and pH, drainage, and light levels.

b. Planting Practices

- *Spacing*- use the correct spacing for the particular plant species; too-close spacing can promote disease by compromising plant vigor and by inhibiting drying and air circulation;
- *Planting*- dig and prepare the planting hole correctly; check for the root flare at time of planting to make sure the tree is not planted too deep or too shallow;
- *Rootball preparation*- for balled and burlapped stock, the burlap and wire basket should be removed, if possible; for container-grown stock, the rootball should be thoroughly moistened, scored, and teased apart before planting;
- *Plant rotation*- it is helpful to purposefully alternate the species grown in a specific area, especially when the disease agent is soilborne.

c. Plant Care

- *Fertilizing*- appropriately timed applications of fertilizer will help to maximize growth and vigor and avoid stress due to nutrient deficiencies or toxicities; fertilizer applications should be based on a soil test and/or tissue analysis; applications of biostimulants and mycorrhizae can also be helpful;
- *Watering*- maintain adequate soil moisture for the plant species; this usually translates to approximately one inch of water per week; in the absence of natural rainfall, irrigation should be used and, depending on soil type, this is best delivered as a deep soaking; avoid overhead irrigation or water plants early in the day to allow foliage to dry before nighttime;
- *Mulching* (summer mulch)- properly applied mulch helps with weed control, soil temperature moderation, soil moisture retention, and reduces the spread of disease; summer mulches should not be applied too thick or too close to the trunk or stem;
- *Winter Protection*- winter mulches, physical barriers, and applications of anti-transpirants or anti-desiccants can be effective in protecting plants from heaving during freeze-thaw cycles and from drying winds.

An example of cultural manipulations that help to reduce disease can be illustrated for winter injury and desiccation of rhododendron, a common problem in Connecticut. Rhododendrons are more prone to this type of injury as well as to fungal leaf spots when they are not properly maintained or when stressed by root injury from drought. These problems can be minimized by maintaining an acidic soil pH, fertilizing in early spring, and watering during periods of drought and just before the ground freezes in the fall.

Sanitation: This option for disease management focuses on minimizing the introduction of disease agents through plant selection and by eradication of diseased plants or plant parts as a means to reduce the potential for spread of biotic agents.

- *Plant Selection*- use of healthy, pathogen-free seedlings and transplants;

- *Prune and Remove Infected Plants and Debris*- symptomatic plants or infected plant parts such as fallen leaves should be promptly removed to minimize disease spread; this practice helps to reduce the amount of overwintering inoculum;
- *Use Clean Equipment*- all tools and equipment should be thoroughly cleaned and disinfested with 10% household bleach (1 part bleach: 9 parts water), 70% alcohol, or a commercial compound such as Greenshield®; bleach can be corrosive so equipment should be thoroughly rinsed in clean water and oiled after treatment;
- *Scout*- check trees on a regular schedule in order to monitor for buildup of diseases and plant abnormalities; keep records for use in outlining management needs for the next year.

An example of sanitation as an essential component for disease control can be illustrated for brown rot, a common and destructive fungal disease of many *Prunus* species in Connecticut. This practice involves removing and destroying mummied fruit on the ground or remaining on the tree and pruning and removing dead and/or cankered twigs. These practices significantly help to reduce the amount of overwintering inoculum that will be available to infect the newly emerging tissues in the spring.

Resistance: This management option utilizes resistant or tolerant cultivars or species of trees to minimize or avoid disease. When available, genetic resistance is probably the most desirable and effective management tool since it circumvents the need for additional controls. It is especially important for diseases caused by viruses, nematodes, and soilborne and wilt pathogens since these are all extremely difficult to control with other means. Although genetically resistant plants are not available for all plants and all diseases, breeding programs are underway and the availability of these types of plants is expected to increase in the near future.

Examples of effective use of genetic resistance include cultivars of crabapple with resistance to scab and rust, cultivars of rose with resistance to powdery mildew and black spot, and cultivars of elm with resistance to Dutch Elm Disease.

Biological: This management tool employs living agents (usually antagonists or competitors of the causal agent) to control plant diseases. Effective biological controls take advantage of the natural competition of living organisms for limited resources or ecological niches. Thus, two organisms cannot occupy the same space at the same time, they cannot consume the same resource (e.g., food source) at the same time, and in some cases, one organism produces compounds that are inhibitory to the growth and development of the other organism.

An example of biological control is the introduction of hypovirulent ("less" virulent) strains of the chestnut blight fungus. These strains compete with virulent strains and keep them from causing killing cankers on infected trees. More detailed information on this topic can be found in numerous *Fact Sheets* about chestnut blight on the CAES website. Several commercial biological control agents have recently become available and are registered for control of some root rot and foliar diseases. Since these products contain living organisms, the directions for storage and use of these products are different than those for conventional pesticides. Thus, careful attention to the label particularly important.

Chemical: Although it is possible to successfully manage many disease problems without the use of pesticides, there are situations where pesticide usage is important and highly successful. Chemical disease control uses pesticides (fungicides, bacteriocides, and nematicides) to limit the effects of biotic agents. Fungicides are the most common chemicals used for disease control. In most cases, however, the degree of control depends on the proper selection, timing, and method of application of the compound. In this regard, selection of the appropriate fungicide is contingent on accurate diagnosis of the problem since fungicides vary in their efficacy; some fungicides are toxic to all or most kinds of fungi whereas others affect only specific types of fungi. Another way of looking at pesticides is as “plant medicines”: these are compounds used to protect or cure plants from infectious agents.

- **Categories of Pesticides:**
    - **“Biorational” pesticides:** these pesticides are defined as products that are considered to be environmentally friendly because they have minimal harmful effects on non-target organisms and the environment; they are frequently more “user friendly” than traditional pesticides; examples include neem oil, insecticidal soap, horticultural oil, sulfur, and potassium bicarbonate.
    - **Biological pesticides:** these are also called biofungicides and contain microorganisms (bacteria or fungi) that are used to control specific plant pathogens; biocontrol agents have multiple modes of action and can act by direct competition (e.g., occupy the same niche or site or compete for the same food source), by predation or parasitism (e.g., attack or kill the pathogen), by antibiosis (e.g., secrete compounds or produce by-products that alter the environment and make it unfavorable for the growth of the pathogen), or by stimulation of the natural defenses of the plant (e.g., induce biochemical changes in the host plant that stimulate growth); examples include *Trichoderma harzianum* var. Rifai. In many cases, biofungicides need to be rotated and/or tank-mixed with other products with different modes of action to avoid pesticide resistance.
    - **“Chemical” pesticides:** these are considered “traditional” pesticides with traditional modes of action; examples include strobilurins, sterol inhibitors, benzimidazoles, coppers, and sulfurs.

- **Protectant *vs.* Systemic Fungicides-** Many fungicides are protectants and must be present on the surface of the plant in advance of the causal agent in order to prevent infection. Their primary mode of action is to inhibit fungal spores from germinating or to kill spores after they germinate and inhibit further growth. These compounds do not stop or cure a disease after it has started since they are not absorbed or translocated within the plant. On the other hand, systemic fungicides are absorbed through the foliage or roots and are translocated within the plant. Products differ in their ability to move from the initial point of contact or absorption. Some products can move upward within the plant, others can move upward and downward. These compounds have a therapeutic (curative) or “kickback” mode of action since they can kill or inhibit growth of pathogens after they have invaded the plant host.

- **Trade Name *vs.* Common Name-** The common name of a pesticide is the name assigned to the active ingredient of the pesticide. In contrast, the trade name of a pesticide is the name assigned by the manufacturer or distributor of a particular product. For example, chlorothalonil is the common name of a fungicide that is sold under many trade names including Daconil WeatherStik®, Echo 90DF®, and Concord DF®. Therefore, a single common name or active ingredient may be available under many different trade names.

When using pesticides for disease control, it is **very important** to thoroughly read and comply with the label. This applies to information on host plants, dosage rates, safety precautions, and days-to-harvest intervals (also called pre-harvest intervals), when applicable.

An example of effective fungicide applications can be illustrated for control of scab of crabapple, one of the most troublesome diseases of apples and crabapples in Connecticut every year. For this disease, the fungus has two distinct cycles of infection (please refer to section on Disease

Cycles, Figure 2). If the pathogen is essentially controlled with properly selected and timed fungicides during the first cycle of infection in the spring, the second cycle does not occur and fungicide sprays are unnecessary for the remainder of the season.

COMMON TREE HEALTH PROBLEMS

A number of diseases are considered of general importance or common occur on many different tree species. The following section covers most of the common abiotic and biotic problems and provides a general description of the symptoms of each disease and the general strategies for managing each problem. Fact sheets with more detailed information for many of these problems can be found in the "Fact Sheet" section of this Guide.

COMMON ABIOTIC PROBLEMS:

1. Drought

Symptoms of drought stress can occur on woody plants in the landscape, in natural woodlots, and in forests. In some cases, the occurrence of drought conditions is obvious, whereas in others, dry condition can be more subtle and might be difficult to discern—when an extended hot, dry period follows a rainy spell. Weather records from the Experiment Station's Lockwood Farm in Mt. Carmel can help to determine when these occur. We often also deal with patterns of several consecutive dry seasons, which can impact many woody plants including drought-sensitive as well as species that are normally considered drought-tolerant. When trying to define a "drought year," the pattern and frequency of precipitation is more important than the total amount of precipitation recorded for the year. Total precipitation levels can be deceiving when interpreted solely on the basis of yearly amounts rather than on a month-by-month basis. This is because one or two significant precipitation events or storms in a year could account for much of the total precipitation recorded for that year. Therefore, it is the amount and frequency of precipitation rather than yearly totals that are important to the long-term health, growth, and vigor of woody plants. This is especially true during the growing season when water demands are the greatest. Up-to-date information on precipitation levels recorded at the Experiment Station's Lockwood Farm can be found on the CAES web site (www.ct.gov/caes).

Drought or dry soil results in damage and death of the roots. The root system of a woody plant has four types of roots: 1) framework roots consisting of primary and secondary woody roots, 2) transport and storage roots, 3) non-woody feeder roots, and 4) root hairs. Almost 99% of this root mass is in the top three feet of the soil. The feeder roots and root hairs, which are in the top 12 inches of the soil, are responsible for uptake of water and nutrients. Unfortunately, they are the first portion of the root system to be affected by drought since they are very sensitive to drying. When feeder roots and root hairs become nonfunctional, a water deficit develops in the plant because these roots can no longer provide sufficient water to the top of the plant. In addition to direct damage to the root system, drought triggers metabolic changes. Among these are changes in hormone levels and other physiological factors (e.g., factors that influence the number of leaves that will emerge the next year or that are responsible for the closing of stomates).

SYMPTOMS:

Symptoms of drought are manifest in many different ways depending on the plant species and the severity of the water deficit. One important aspect of drought is the fact that the symptoms are often not evident in the top of the tree or shrub until sometime after the event has occurred--even as much as one to two years later. Symptoms include loss of turgor in needles and leaves, drooping, wilting, yellowing, premature leaf or needle drop, bark cracks, and twig and branch dieback. Leaves on deciduous trees often develop a marginal scorch and interveinal necrosis whereas needles on evergreens turn brown at the tips. Trees and shrubs can also exhibit general thinning of the canopy, poor growth, and stunting. In extreme cases, drought can result in plant death.

In addition to direct root damage, a significant secondary effect of drought is that it weakens plants and predisposes them to secondary invaders and opportunistic pests such as fungal tip blights, vascular wilts, root rots, and needlecasts. Many drought-stressed plants also show increased sensitivity to de-icing salts, air pollutants, and pesticides to which they are exposed. Native plants growing naturally in woodlots or forested areas are usually adapted to regional and seasonal fluctuations in the amount of precipitation and only *unusually* severe drought causes problems for them. However, planted landscape trees and shrubs often show symptoms of drought and severe water stress. Planting practices are frequently key sources of this problem since we often plant in unfavorable sites, don't prepare the rootball properly, plant too deep or too shallow, or mulch so thickly that water doesn't penetrate into the soil.

Symptoms of drought can develop on a wide range of deciduous and evergreen trees and shrubs and are particularly severe on seedlings and new transplants. This is because their roots occupy the uppermost layers of soil where the most rapid drying occurs. In addition, recent transplants typically lose important feeder roots during the transplant process. For example, balled and burlapped trees are estimated to contain only 5-20% of their original root mass after digging. For container-grown ornamentals, the medium in which the transplant is growing can be a key factor--many of the soilless mixes used for container stock are highly porous, dry out very quickly, and are very difficult to re-wet. This situation creates moisture stress in the rootball regardless of the availability of water in the surrounding soil. This problem often continues until the roots grow beyond the rootball. Contrary to popular opinion, it often takes woody transplants two years to become completely established in a new site. Thus, these plants should be given extra care and attention during periods of drought. Established trees and shrubs are also affected by drought, especially those in marginal sites, i.e., with pavement over their roots, street trees, in pockets of soil on ledges, or in sandy soils. Problems have also been observed on apparently established trees and shrubs that have survived despite improper planting. Once stressed by drought, these trees quickly decline and often die.

MANAGEMENT STRATEGIES:
While there is no cure for this problem, the effects of drought can be minimized by following some preventative measures:

- Water in periods of low soil moisture: trees and shrubs require approximately one inch of water per week. This is best applied at one time as a slow, deep soaking to a depth of approximately 12-18 inches. The length of time required to "deep-water" will vary depending on soil type and water pressure: clay soils usually require more time than sandy soils. Frequent, light, surface watering will ***not*** help the tree and can actually cause harm by promoting growth of surface roots. A deep soaking just before the ground freezes in the fall will also help the winter hardiness of drought-stressed plants.
- Select an appropriate site and follow good planting practices; drought stress can magnify even subtle improper planting practices.
- Select native plants or match plant species to site conditions: drought-sensitive (dogwood, some oaks, arborvitae) *vs.* drought-tolerant (most pines, many *Prunus*, larch, junipers).
- Mulch to maintain soil moisture.
- Prune any dead or weakened tissues to avoid secondary problems.
- Maintain plant vigor by following good cultural practices.

2. Excess Water
Excess water can be a serious problem for many woody ornamentals. Roots in flooded or waterlogged soils are damaged and die from oxygen deficiency. In addition to this direct damage to the root system, flooding has also been associated with inciting physiological changes in woody

plants that influence their growth and other processes. The feeder roots, which are non-woody and important for uptake of water and nutrients from the soil, are particularly sensitive and are frequently the first ones damaged by waterlogged conditions. Woody roots are more tolerant than non-woody roots to flooding. When feeder roots are damaged, they are unable to provide water to the top of the plant and a water deficit develops. Damage can be sudden or gradual, depending on the plant and the flooding conditions. This can occur on plants in obviously wet sites and on those in marginal sites or soils with more subtle water problems such as along city streets or in areas where high clay content in the soil impedes drainage. Most trees and woody shrubs cannot grow in waterlogged soils for very long and can die if flooded for only a few days during the growing season. Visible symptoms are *often* not evident until considerably after the damage has occurred, especially when the root damage is gradual.

SYMPTOMS:
Symptoms of excess water depend on the plant and are highly variable. These include epinasty or downward rolling of leaves, stem swelling, chlorosis or yellowing of the foliage, oedema, reduced and stunted growth, twig dieback, leaf drop, root death and, in extreme cases, whole plant death.

Seedlings and new transplants are more sensitive to excess water problems than are established plants. This can be attributed to the lack of an established root system and to feeder root damage during transplanting. Needled evergreens are generally considered more sensitive to waterlogged soils than broadleaved deciduous plants. Symptoms of waterlogging may not develop in a woody ornamental until water demands on the root system increase, typically during the hot summer months when the canopy is actively losing water through transpiration. This is sometimes exhibited as a sudden collapse of the tree or shrub. Other trees appear to lose vigor and slowly decline over a period of years. This can occur on trees that have been otherwise "healthy" for 10-15 years but are growing in poor sites or heavy soils. Dormant plants generally appear to tolerate flooding longer than those in active growth. In addition to direct root damage, trees in flooded soils are predisposed to secondary pathogens and other opportunistic pests such as the fungal root rots caused by *Phytophthora* and *Armillaria*.

MANAGEMENT STRATEGIES:
Strategies for minimizing wet soil problems include:

- Select an appropriate site and follow proper planting practices.
- Follow cultural practices that maintain plant vigor.
- Select the appropriate species for soil and site conditions: water-tolerant (red maple, larch, green ash) *vs*. water-intolerant (crabapple, spruce, hemlock, yew, white pine).
- Prune dead or dying tissues to minimize secondary invaders and opportunistic pests.

3. Winter Injury
Weather conditions during the past few winters in Connecticut have been conducive to plant injury. The impact of these conditions is evident in ornamental plantings in the landscape as well as in woodlands throughout the state. The factors that cause this type of injury are diverse and problems often don't appear on woody ornamentals until the spring and summer. In addition, the extent and severity of the injuries that develop are often more extreme on plants weakened from drought stress.

Winter injury results from many environmental factors that have little in common other than that they occur during the winter. Examples of these diverse factors include late spring frosts, cool summers followed by warm autumns and sudden drops in temperature, dramatic temperature fluctuations, freeze-thaw cycles, lack of snow cover, reflected heat from snowcover, unusually warm midwinter temperatures, extended periods of extreme or abnormally cold temperatures, and drying winds. For example, when freezing conditions follow a gradual drop in temperature, they are seldom harmful to most woody ornamentals provided the tissues are mature and have started to go dormant. However, if plant tissues are not mature or have not entered dormancy, they are unable to withstand freezing conditions and injury results. The injury is often confined to the immature, succulent shoots and the damage appears as a dieback of the terminals once growth begins in the spring.

Winter injury is important in and of itself but it also predisposes and weakens plants and subsequently makes them more vulnerable to secondary or opportunistic pests. Among these secondary problems are unusually high incidences of branch and twig diebacks such as those caused by *Botryosphaeria* spp. and *Phomopsis* spp., fungi that are normally not considered to be aggressive pathogens. Another important characteristic of winter injury is that quite often the symptoms are not evident until sometime after the injury has occurred. This can make accurate diagnosis very difficult. For example, winter damage to sapwood of lilacs may not be evident until spring or early summer when branches suddenly collapse and die.

Winter injury can occur on a wide range of plants. However, it is often particularly problematic on evergreens in the landscape. This includes broadleaved evergreens such as rhododendron, mountain laurel, and holly and needled evergreens such as hemlock, arborvitae, chamaecyparis, pine, and juniper. Deciduous trees and shrubs such as flowering cherry and almond, maple, and dogwood are also damaged by winter injury as are ground covers such as ivy and pachysandra.

SYMPTOMS:

Symptoms of winter injury are quite variable and depend on the type of plant. Woody plants that are damaged by winter injury will often show tip and branch dieback, foliar browning, sunscalding, and bark splitting. One type of winter injury is excessive drying. This is quite common on evergreens and results from factors that create a water deficit in the plant. This type of injury occurs when water evaporates from leaves or needles on windy or warm, sunny days during the winter or early spring. Drying occurs because this water is not replaced since the roots cannot take up enough water from cold or frozen soil. On broadleaved evergreens such as rhododendron and mountain laurel, the most familiar leaf symptom is characterized by a marginal browning and longitudinal rolling along the midvein. In some cases, entire branches or shrubs can be affected. Needled evergreens exhibit a slightly different symptom with browning of the tips or center portions of needles, chlorotic flecking, needle drop, and tip and twig dieback. In extreme cases, an entire shrub or tree may turn brown or appear off-colored.

On deciduous trees and shrubs, bark may be injured or split by cold weather. Cracks and dead areas appear in the bark and the bark begins to peel away from the trunk as the tree grows in spring and summer. This type of damage is common on many of the thin-barked species such as crabapples, cherries, and maples. Frost cracks during dormancy result from the expansion and shrinkage of bark and wood, which causes internal mechanical stress and cracking and splitting of wood and slipping of bark at the cambium layer. Extremely cold winter temperatures also result in damage to flower and leaf buds. Buds can also be damaged by periods of unusually warm winter temperatures, which trigger them to begin to break dormancy. When the normal temperatures return, these tender buds are injured. As a consequence of both types of injury, deciduous trees and shrubs may not flower or may fail to leaf out properly in the spring. Cold temperatures occasionally cause sub-lethal or lethal damage to cambial tissues. This type of injury usually doesn't appear early in the season but causes new branches to suddenly wilt and begin to die back by early to midsummer. Injured tissues apparently cannot keep up with the water demands of actively growing plants and the plants collapse.

MANAGEMENT STRATEGIES:

Although the weather cannot be controlled and there are no "cures" once the damage is done, there are steps that can minimize the effects of winter injury. These include:

- Select the appropriate site for planting and maintain optimum growth by following sound cultural practices.
- Select native plants or match plants to the site; for example, avoid planting broadleaved evergreens in open, windy locations where they will be subjected to drying winter winds.
- Provide sufficient moisture to the root zone before the soil freezes--this can be accomplished by giving the trees (esp. evergreens) a deep watering before the ground freezes in the fall; mulching also helps to increase moisture retention in the winter.
- Avoid late summer and early fall fertilization, which may stimulate and encourage growth late in the season that may not harden-off properly for the winter.
- Prune and remove any dead twigs or branches, which can serve as sites for secondary invaders or opportunistic pests.
- Provide physical protection from water loss and drying winds--this is especially important for new transplants or plants in exposed locations; burlap wraps and sprays of anti-transpirants can be used.

4. De-Icing Salts

De-icing salts used to maintain ice-free roadways, driveways, and sidewalks cause damage to woody ornamental trees and shrubs in several ways. Although there has been increasing concern about the environmental impact and adverse effects of de-icing salts in recent years, these issues have been overshadowed by concerns for public safety. In fact, as much as 40-80 tons of salt per lane mile are applied to many highways for ice and snow control each year. The two most commonly applied de-icing salts are sodium chloride (rock salt) and calcium chloride. Although calcium chloride is a better material for melting ice, sodium chloride is used more extensively since it is less expensive and easier to handle. Unfortunately, sodium chloride is also more damaging to vegetation than calcium chloride. Salt can injure plants at anytime but applications in late winter (March) are thought to be more damaging than early- to midwinter applications since there is less time for winter snow and precipitation to leach the salts from the root zones.

DAMAGE AND SYMPTOMS:

De-icing salts cause damage through direct contact of salt solutions with plant foliage (referred to as "spray zone" injury) and through chemical and physical modification of the soil as a result of accumulating salt and uptake of salt ions by plant roots. Spray zone injury results from the deposition of salt water on plant foliage and subsequent uptake of the salt by that foliage. Salt enters plant cells or the spaces between plant cells directly and can affect the hardiness of buds and small twigs. In the soil, dissolved salts separate into sodium and chloride ions that chemically and, to a certain extent, physically modify the soil. The chloride ions are readily taken up by the plant roots and transported to growing tips and foliage where they accumulate to toxic levels. In needles and leaves, these toxic accumulations result in marginal scorch or "burn" symptoms. The sodium ions also cause damage by competing with other ions in the soil. When high levels of sodium ions compete with lower levels of magnesium and potassium ions, it often results in selective uptake of sodium at the expense of the other two important nutrients. When this occurs, plants may develop deficiency symptoms, particularly those associated with potassium deficiency.

Symptoms of de-icing salt injury resemble those associated with root damage or drought stress. They vary with salt concentration, length of exposure, and plant species. Common symptoms include foliar browning, tip necrosis, marginal scorch, leaf and needle drop, tip and branch dieback, premature fall coloration (deciduous species), death of vegetative buds as well as flower buds, and in extreme situations, outright tree death. One diagnostic feature of salt injury is that symptoms are often confined to the side of the tree or shrub facing the road and usually occur within 30-50 ft. of the road. Additionally, a gradient of damage can often be seen with trees closer to the road showing more damage than those farther back.

Woody ornamentals show considerable variation in their relative tolerance to de-icing salts. However, research has demonstrated that trees and shrubs that have been weakened by drought stress are more sensitive to de-icing salts than their healthy counterparts. Among those with high tolerance are Norway maple, autumn olive, white ash, white oak, honeylocust, Japanese black pine, white spruce, and yew. Moderately tolerant species include black cherry, green ash, American elm, Scots pine, and red cedar. Salt-sensitive species include winged euonymus, viburnum, sugar maple, dogwood, little-leaf linden, sycamore, eastern white pine, balsam fir, and Canadian hemlock. More extensive lists are available upon request.

MANAGEMENT STRATEGIES:

Although ***preventing*** problems with de-icing salts is certainly the best solution, it is not always practical or possible. However, the damage associated with de-icing salts can be managed or minimized using a number of different strategies. These include:

- **Washing salts off foliage**- Excess salts can be washed off foliage and should be done as soon after exposure as possible.
- **Minimizing snow piles**- Avoid piling snow containing salt around plants or in places where the runoff will affect desirable plants. It is also helpful to alter road or walkway drainage patterns away from desirable plant species.
- **Removing sand**- Since de-icing salts are often used in combination with sand, buildup of sand can sometimes present additional problems. Sweeping, "brooming," or any other method that physically removes sand that has accumulated on the soil surface will be helpful. Since the type of sand applied to roads is extremely sharp, it is not a desirable addition to native soil. Thick layers of sand will also inhibit gas exchange and water penetration into the root zones of desirable plants.
- **Leaching salts-** To whatever extent possible, salts should be leached from the root zones of affected plants as soon as the ground is no longer frozen. *This is probably the most effective way to minimize soil salinity problems.* Repeated applications of fresh water will help to flush the salts down into the soil profile, below the root zones. The amount of water required to leach the salts will depend on the salinity level. Leaching of excess salts can, however, be difficult in heavy clay soils, which do not have good internal drainage.
- **Amending soil**- Additives to the soil such as organic matter, activated charcoal, and gypsum can help with rectifying soil salinity problems. However, these are not quick fixes and if the salinity levels are extremely high, no amendments will reverse the situation. All additives, regardless of the material used, need to be incorporated into the soil, usually to a depth of at least 6 inches. This need to incorporate the amendment is one of the limiting factors in using soil additives to counter road salt problems. Although a few reports suggest surface applications can be helpful (particularly for gypsum), the general consensus maintains that the additives need to be fully incorporated in order to be effective. Since plants growing in soils rich in organic matter show increased tolerance to salt, a program to increase organic matter in areas prone to road salt is a good preventative plan. Gypsum ($CaSO_4 \cdot 2H_2O$) is the most common additive used to counter salinity problems associated with sodium chloride,

the most common de-icing salt. Gypsum separates into calcium and sulfate in the soil. The sulfate forms sulfuric acid in the soil and helps to neutralize any effect that calcium may have in raising the soil pH. The calcium replaces the sodium on the cation exchange sites. The sodium and sulfate form sodium sulfate ($NaSO_4$), which is a product that can be leached from the soil with water. Rates for gypsum applications depend on the salinity of the soil. However, rates in the range from 10-50 lbs. per 100 sq. ft. are commonly suggested.

- **Determining salt levels**- If concerned about the level of salt with which you're dealing, a soil test can help. Soil salinity is determined by measuring the electrical conductivity of the soil solution. This can be done with soil samples taken from the root zones of the areas in question. Testing for soluble salts is not part of the normal soil test performed by The Connecticut Agricultural Experiment Station. However, soluble salt levels can be tested *when requested at the time the soil sample is submitted for analysis.*
- **Selecting plants**- In areas where de-icing salt is likely to be a chronic problem, it is important to select and plant salt-tolerant species.
- **Maintaining plant vigor**- Maintain overall plant vigor by following sound cultural practices, which include watering during periods of drought and pruning of dead or weakened branches or twigs, in order to minimize problems with secondary or opportunistic pests.

5. Misapplied Pesticides

Injury from misapplied pesticides, mostly herbicides, has increased dramatically over the past few years. In part, this increase can be attributed to widespread use of broadleaved weed controls applied to turf in addition to careless application methods or misapplication of herbicides in the root zones of woody ornamentals. The symptoms vary with compound and plant species and can develop several days to weeks after exposure and, in some cases, even the following spring. Symptoms on broadleaved and deciduous trees include chlorosis, necrotic spotting, marginal scorch, leaf cupping, curling, bud death, tree dieback, decline, deformed leaves, and sometimes death. On conifers, symptoms include needle browning, drop, dieback, bud death, twisting, growth abnormalities and, in extreme cases, tree death. Plant species vary with regard to their reaction to specific pesticides and lists of the relative sensitivities of various species are available.

The herbicides 2,4-D, MCPP, and dicamba most frequently cause problems. These compounds act as plant hormones that disrupt normal growth processes in affected plants. Doses can be lethal (when trees are killed as a result of exposure) or sub-lethal (when trees recover over time). Trees are injured in basically three ways: 1) from spray drift--direct plant contact from droplets containing the compound; 2) from vapor drift--direct plant contact through gaseous, vaporized compounds, usually associated with highly volatile pesticides or with high temperatures; and 3) from root absorption--herbicides are leached into the soil and root zones of non-target plants.

MANAGEMENT STRATEGIES:

- **Prevention** through careful application is the best control.
- Avoid drought stress since drought-stressed plants are more vulnerable.
- Select less sensitive species in areas where continued herbicide use is necessary.

COMMON BIOTIC PROBLEMS

1. Foliage Diseases

These comprise the most common of all plant diseases that we encounter in the landscape. In most cases they are considered to be more aesthetic than life-threatening problems although they can result in significant premature leaf drop. These diseases are typically most serious during wet springs since free water on leaf surfaces is usually necessary for infection. The causal agents include a wide range of fungi and bacteria. Hosts are a broad range of deciduous and broadleaved evergreen trees and shrubs.

Leaf Spots: These are the most prevalent of all plant diseases. Leaf spots appear as dead areas scattered over the leaf surface. The size, color, and shape can vary with host and pathogen although they usually have definite margins. Leaf spots can result in substantial premature defoliation. Examples include Tar Spot of Maple, Scab of Crabapple, and Oak Leaf Blister.

Anthracnoses: These appear as necrotic areas that are often V-shaped and defined by the veins. Symptoms can appear as blotchy, dead areas or as discrete leaf spots. Severe infections can result in significant defoliation and, occasionally, in twig and branch dieback. Anthracnoses are most serious during wet, cool springs. Examples include Anthracnoses of Sycamore, Maple, Dogwood, and Ash.

Needlecasts: Infected trees are characterized by browning and chlorosis of the needles and by premature and often severe needle drop. Symptoms can also be associated with branch and twig dieback. Examples include Rhabdocline Needlecast of Douglas-Fir, Rhizosphaera Needlecast of Spruce, and Dook's Needlecast of White Pine (formerly Canavirgella Needlecast).

Powdery Mildews: Symptoms appear as grayish or white, powdery growth, usually first evident on the upper surface of the leaf but it can occur on both leaf surfaces. Symptoms can vary with each host and can result in minimal or extensive, premature fall coloring, browning, and defoliation. Powdery mildews usually develop mid to late in the growing season. Examples include Powdery Mildew of Dogwood, Maple, Oak, and Elm.

Rusts: These are recognized as brightly-colored, often yellow to red or orange, raised blisters or pustules that develop on leaves. The pustules break open to reveal the orange to rusty-brown spores for which these diseases are named. On evergreens, symptoms can also develop as galls or swellings on twigs and branches. Examples include Cedar-Apple Rust, Hawthorn Rust, and Spruce Needle Rusts.

MANAGEMENT STRATEGIES:

- Maintain tree or shrub vigor by fertilization and watering during periods of drought.
- Rake and remove symptomatic fallen leaves in autumn.
- Prune out dead branches or twigs in spring.
- Use resistant cultivars when available.
- Most foliage diseases are not serious enough to warrant chemical control; however, there are exceptions with regard to the value of the plant or tree, the specific host and type of leaf spot involved, the nature of the host-associated damage, and the timing of defoliation; most available fungicides are protectants and must be applied to developing foliage **before** symptoms appear; the number of sprays required for control will vary with weather conditions; check pesticide labels for plant host, pathogen, dosage rates, and safety precautions.

2. Blight and Dieback Diseases

These diseases are characterized by sudden and conspicuous leaf and growing tip damage, blackening or wilting of growing tips, and death of shoots and growing tips. They are often more severe during wet weather or on plants that have been stressed by other factors. The causal agents commonly include a wide range of fungi and bacteria that are capable of infecting a broad range of deciduous and evergreen trees and shrubs. Examples include Diplodia Blight of Pine and Fire Blight of crabapple and pear.

MANAGEMENT STRATEGIES:

- Avoid plant stress and maintain vigor.
- Protect plants from winter injury.
- Use resistant cultivars when available.
- Prune, remove, and destroy diseased portions of plants, especially spent flowers and leaf debris.
- Fungicides are helpful in some host-pathogen combinations; many are protectants and need to be applied before symptoms appear and the effectiveness and number of sprays required for control will vary with weather conditions.

3. Vascular Diseases (Wilts)

Wilts are characterized by loss of rigidity, wilting, yellowing of foliage, and drooping of plant parts. These are often followed by premature defoliation and gradual dieback or "flagging." With flagging, one limb or branch becomes symptomatic at a time. Infected trees will occasionally produce a heavy crop of seed and have leaves that are smaller than normal. Depending upon the causal agent, infected branches may develop characteristic brown, greenish, or yellow streaks in the vascular tissues. Phytoplasmas and several types of fungi can cause wilts. Depending on the causal agent, **many** tree species can be infected. However, trees under drought, nutrient, or salt stress are generally more sensitive. Examples of wilt diseases caused by phytoplasmas are Ash Yellows and Elm Yellows. The most common fungal wilts are Verticillium Wilt *(Verticillium dahliae*) and Dutch Elm Disease *(Ophiostoma novo-ulmi).*

MANAGEMENT STRATEGIES:

- Prune and remove affected branches or limbs as soon as symptoms are evident; cuts should be made well below visible symptoms.
- Plant resistant species where possible.
- Maintain plant health by following sound cultural practices.
- Avoid tree stress by selecting an appropriate planting site.
- Some success has been achieved with fungicide injections.

4. Branch and Stem Canker Diseases

Canker infections may appear as definite areas that vary in color from the surrounding healthy bark. These can be necrotic, often sunken or swollen lesions on twigs, branches, limbs, or the main trunk. When cankers girdle the twig or branch, leaves wilt, drop, and the distal portion of the branch dies. Causal agents include a wide range of fungi and bacteria and sometimes small fruiting structures of these causal fungi may be evident in the canker. Hosts include a wide range of hardwoods and conifers. Examples include Cytospora Canker of Spruce, Black Knot of Cherry, Coral Spot Canker, and Botryosphaeria Canker.

MANAGEMENT STRATEGIES:

- Prune and remove symptomatic branches; in some cases, trunk cankers can be surgically excised during dry weather.
- Maintain tree vigor.
- Avoid wounds and pay careful attention to pruning techniques.

5. Root Diseases

Root diseases are associated with symptoms that are usually nonspecific. Leaves turn yellow, wilt, and droop, twig and branch dieback may occur, trees exhibit general decline, reduced or stunted growth, and trees may die. The causal agents are varied but fungi are the most common. A wide range of hardwoods and conifers can be infected, however, plants under stress, especially from excess water, are more susceptible. In most cases, once trees are infected they cannot be cured. Examples include Armillaria Root Rot, Phytophthora Root Rot, and Crown Gall.

MANAGEMENT STRATEGIES:

- Protect plants from soil moisture extremes (drought or flooding).
- Maintain tree vigor.
- Remove and destroy affected trees; removing stumps and woody roots is often prudent and necessary.
- Plant resistant species, where possible.
- When available and applicable, biocontrol agents or fungicides can be applied to protect healthy trees nearby.

PROBLEMS OF UNDETERMINED CAUSE:

"Decline" Syndromes

Tree decline is characterized by progressive deterioration due to loss of vigor and health. Trees can decline for **many** reasons and although one factor may be responsible, in most cases decline results from several factors. These factors, which are often both biotic and abiotic, can act singly or in combination. A key aspect of tree decline is that the causal factors are active **over a period of years**. Symptoms of decline are highly variable and are dependent upon cause(s) and tree species. They include slow growth, sparse canopy and undersized leaves, premature leaf drop and fall coloration, excessive fruit set, and dieback of twigs and branches. Causal factors are many and include a wide range of abiotic (e.g., extremes of heat or moisture, girdling roots, construction damage or injuries) and biotic (e.g., primary pathogens such as *Verticillium* and phytoplasmas, opportunistic pathogens, insects causing defoliation) factors. Any tree or shrub can be affected by decline but some species are more frequently affected. In Connecticut these include ash, oak, and maple (Ash Decline, Oak Decline, and Maple Decline).

MANAGEMENT STRATEGIES:

- Select plants appropriate for the site.
- Maintain vigor with special attention to watering during drought.
- Avoid physical, mechanical, and chemical injuries.
- Prune and remove any dead or dying branches or limbs.

Disease Management Guide

Abies (Fir)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Armillaria Root Rot *(Armillaria* spp. *complex)* p. 326	Also called shoestring root rot and honey mushroom rot; this disease is difficult to identify since aboveground symptoms appear as general and progressive decline that leads to the eventual death of trees; trees can die singly or in groups; trees under environmental or site-related stresses are particularly susceptible; on conifers, excessive resin production at points of infections or at the bases of trees can be important symptoms of infection; the diagnostic black strands of the fungus called rhizomorphs (shoestrings) are usually not present on conifers; signs of the infection includes white fans of fungal growth with “mushroomy” odors under the bark and the occasional growth of honey mushrooms at the base of infected trees in autumn; the fungus can persist in stumps and large, woody roots for as long as 30 years.	• maintain tree vigor; • avoid any unnecessary stresses, esp. drought stress; • avoid planting susceptible trees in a site where this disease has been confirmed; • if replanting in the site, the stump and all woody roots greater than ½ inch in diameter should be removed.	No chemical control is suggested.
Canker *(Leucostoma, Cytopsora, Valsa)* p. 166	Symptoms include needle browning, bare twigs, and dead or dying branches; most obvious in spring and early summer; associated with cankers that appear as sunken, dead areas on branches or main trunk; cankers are sometimes difficult to see but excessive resin flow can be used as an indicator of cankered areas.	• avoid wounding trunk and limbs; • maintain vigor; • prune and remove diseased limbs back to healthy wood when bark is dry and disinfest tools between cuts; • avoid unnecessary stresses, esp. drought stress.	No chemical control is suggested.

Abies (Fir) cont'd

Disease *(Pathogen/Cause)*	Diagnostic Symptoms	Management	Materials
Diplodia Blight [Sphaeropsis Tip Blight] (*Diplodia pinea*) p. 130	Tip blight results from infection of newly emerging buds and shoots; infected buds or shoots usually stop growing before or during needle elongation and needles are frequently stunted and short; infected tissues are straw-colored and have excessive resin flow; usually kills only current-season buds and shoots and second-year cones, but can cause significant dieback of larger limbs on stressed trees; black fruiting structures of the fungus may be visible at the base of needles and on cones; symptoms may be distributed uniformly throughout the canopy or concentrated in lower branches; drought-stressed trees are particularly susceptible; can be destructive for 2 and 3- needled species; recent research suggests the fungus is capable of causing latent infections that can go undetected until the tree is exposed to periods of stress when the fungus is activated and dieback symptoms develop; refer to fact sheet for more detailed information.	• prune and remove blighted twigs, branches, and cones during dry weather in autumn; • maintain tree vigor; special attention should be given to watering during periods of drought; • fungicide sprays can be applied at budbreak and repeated 2-3 times at label intervals; additional sprays may be necessary during rainy, prolonged budbreak.	chlorothalonil + thiophanate-methyl *copper hydroxide copper sulphate pentahydrate mancozeb mancozeb + copper hydroxide *potassium bicarbonate propiconazole thiophanate-methyl triadimefon

Abies (Fir) cont'd

Disease *(Pathogen/Cause)*	Diagnostic Symptoms	Management	Materials
Fungal Needlecast *(Lophodermium)* p. 46	Needles turn yellow, brown, and drop prematurely; diagnostic, elongate, football-shaped fruiting bodies of the fungus may be evident on the infected needles;	• rake and remove symptomatic needles; • maintain tree vigor; • chemical control is usually not necessary except for new transplants, young, or specimen trees, or when defoliation has been heavy for several years; fungicide sprays can be applied in late June or early July and repeated according to label directions.	chlorothalonil copper sulphate pentahydrate mancozeb thiophanate-methyl
Phytophthora Root Rot *(Phytophthora* spp.*)* p. 362	General decline, poor growth and vigor due to root decay; needles become chlorotic, droop, and brown; symptomatic trees may occur singly or in enlarging groups; can result in tree death; excessive resin is sometimes visible on the outer bark at the base of the tree; a diagnostic brown discoloration may be evident on the inner bark and cambium at the root/crown area; frequently more serious on trees in sites where excess water is a persistent problem (e.g., clay soils, low areas); seedlings are highly sensitive; Fraser fir is particularly susceptible.	• avoid excessive fertilization and planting in wet areas; • protectant fungicides can be applied to uninfected, asymptomatic trees adjacent to infected trees; infected trees cannot be cured.	fosetyl-Al mefenoxam mono- and di- potassium salts of phosphorus acid phosphorous acid

Abies (Fir) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Rusts *(Uredinopsis, Pucciniastrum)* p. 280, 276	Yellow, orange, reddish-brown, or white pustules develop on needles; infected needles usually dry up, turn brown, and drop by late summer; most rust fungi require alternate hosts to complete their life cycles; fir-fern or Uredinopsis needle rust (*Uredinopsis pteridis*) has been prevalent on white and grand fir in landscape and plantation trees in Connecticut; the alternate host is bracken fern; refer to fact sheet for more detailed information.	• maintain tree vigor; • control measures are usually not necessary except in Christmas tree plantations or for specimen trees; • fungicides can be applied when new growth emerges in the spring and repeated according to label directions; do not use triadimefon on Concolor (white) fir; • remove alternate hosts, when applicable.	azoxystrobin mancozeb triadimefon
Sirococcus Tip Blight *(Sirococcus)* p. 118	Symptoms first appear on succulent shoots and 1-year-old twigs; the fungus attacks at needle bases, girdles the shoot, and results in tip dieback; affected tips turn brown, drop needles, and often develop a characteristic crook or droop; pinpoint, brown fruiting structures may be visible along the stems of dead shoots; infections can appear at random in the canopy; refer to fact sheet for more detailed information.	• prune and remove infected shoots when bark is dry; • rogue and remove heavily infected trees; • maintain vigor; • fungicide sprays can be applied when needles are ½ inch long and repeated 2-4 times at label intervals until needles are fully expanded.	azoxystrobin chlorothalonil chlorothalonil + thiophanate-methyl mancozeb

Acer (Maple)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Anthracnose *(Discula, Aureobasidium)* p. 96, 110	Irregular, brown to reddish-brown (often papery) areas develop along and sometimes between veins and at leaf margins; symptoms are very similar to those associated with drought and heat stress; some defoliation may occur when infection is heavy; can result in tip dieback; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • prune dead twigs and branches; • chemical control is usually not necessary except for new transplants, young or specimen trees, or when defoliation has been heavy for several years; fungicide sprays can be applied at budbreak and repeated 2-3 times at label intervals.	azoxystrobin chlorothalonil chlorothalonil + thiophanate-methyl copper sulphate pentahydrate mancozeb mancozeb + copper hydroxide mancozeb + thiophanate-methyl thiophanate-methyl
Bleeding Canker *(Phytophthora* spp.) p. 354	Primary symptoms include oozing of reddish-brown fluid from fissures or cracks in the bark; these are usually centered over diffuse cankers; infected inner bark, cambium, and sapwood appear distinctly reddish-brown; some dieback of branches and thinning of the canopy can occur; can result in tree death; quite prevalent in landscape trees in 2006 growing season.	• maintain tree vigor by attention to irrigation, soil compaction; • mildly infected trees have occasionally been reported to recover; • rogue and remove heavily infected trees to reduce the potential of spread to nearby trees; • recent trials have demonstrated <u>anecdotal success</u> with directed basal bark sprays and injections of mono- and di-potassium salts of phosphorus acid.	mono- and di-potassium salts of phosphorus acid phosphorus acid

Acer (Maple) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Botryosphaeria Canker *(Botryosphaeria spp.)* p. 120	Random dieback of branches and limbs; usually associated with sunken cankers in which black fruiting structures of the fungus may be visible; problematic on trees weakened by other factors such as site or drought.	• prune affected limbs back to healthy wood as soon as detected and when bark is dry; • avoid wounding; • maintain tree vigor; • avoid unnecessary stresses, esp. drought stress.	No chemical control is suggested.
Decline *(Abiotic Complex-Unknown)* p. 460	General poor growth and vigor; progressive dieback and thinning of the canopy; premature fall coloration.	• avoid stress by attention to planting site; • maintain tree vigor; • avoid exposure to road salt and minimize soil compaction; • prune dead branches.	No chemical control is suggested.
Eutypella Canker *(Eutypella parasitica)* p. 196	General dieback and thinning of the canopy; cankers can develop on branches or the main trunk; Eutypella cankers are distinctly different from Nectria cankers; they have a pronounced bulge of callus around a dead center; cankers consist of somewhat flattened, concentric rings of callus; these weak areas are prone to storm breakage.	• avoid wounding trunk and limbs; • maintain vigor; • prune and remove diseased limbs when bark is dry and disinfest tools between cuts.	No chemical control is suggested.

Acer (Maple) cont'd

Disease *(Pathogen/Cause)*	Diagnostic Symptoms	Management	Materials
Fungal Leaf Spot (*Phyllosticta)* p. 42	Circular spots approx. ¼ inch in diameter with tan to brown centers and distinct purplish-brown margins develop on leaves (sometimes referred to as a "frog-eye" symptom); small, black fruiting bodies may be visible on upper surfaces of spots; usually more severe on red, sugar, and silver maple but can occur on Japanese and Norway maple; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • prune dead twigs and branches; • chemical control is usually not necessary except for new transplants, young or specimen trees, or when defoliation has been heavy for several years; fungicide sprays can be applied at budbreak and repeated as necessary at label intervals.	azoxystrobin chlorothalonil chlorothalonil + thiophanate-methyl copper sulphate pentahydrate mancozeb mancozeb + copper hydroxide mancozeb + thiophanate-methyl thiophanate-methyl
Girdling Root *(Abiotic)* p. 504	Roots growing closely appressed to the main trunk result in poor vigor, weak growth, general decline, and canopy dieback; symptoms often develop on one side of a tree; girdling roots develop at or below the soil line; a diagnostic symptom is a "telephone pole" appearance to the base of the tree (i.e., lack of a root flare); Norway maple is prone to this problem.	• maintain vigor; • examine young trees, especially Norway maples, during the first 10 years after planting for any symptoms; if a girdling root at an early stage of development is found, it can be excised and removed; • prune and remove any dead branches.	No chemical control is suggested.

Acer (Maple) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Nectria Cankers (Coral Spot Canker, Perennial Canker) *(Nectria* and Neonectria) p. 176, 182	Random dieback of branches and limbs; usually associated with sunken cankers that are often covered with distinctive coral-colored or reddish-orange fruiting structures of the fungus; problematic on trees weakened by other factors such as drought.	• prune affected limbs as soon as detected when bark is dry; • avoid wounding; • maintain tree vigor; • avoid unnecessary stresses, esp. drought stress.	No chemical control is suggested.
Powdery Mildew *(Erysiphe)* p. 8	White to grayish, powdery growth on leaves, usually first evident on upper leaf surfaces but can occur on both surfaces of leaves; develops fairly late in the season; some premature fall coloration and leaf drop may occur; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • avoid excessive fertilization since tender, succulent leaves are more susceptible; • provide good air circulation around the tree; • spraying is usually not necessary since the disease has no significant impact on tree health; on specimen trees, fungicides can be applied as soon as symptoms are evident and repeated as necessary.	chlorothalonil + thiophanate-methyl copper sulphate pentahydrate fenarimol mancozeb + myclobutanil myclobutanil thiophanate-methyl triadimefon
Scorch *(Abiotic)* p. 492	Irregular, brown to reddish-brown (often papery) areas develop along veins or at leaf margins; symptoms are very similar to those caused by anthracnose and occasionally by heavy feeding damage from leafhoppers.	• avoid plant stress, especially drought stress; • promote tree vigor and pay attention to planting site.	No chemical control is suggested.

Acer (Maple) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Tar Spot *(Rhytisma* spp.*)* p. 66	Distinctive, shiny black, tar-like spots develop on leaves; depending on the fungal species, spots can be irregular and range from ½ - 1 inch in diameter or can appear as clusters of tiny, pinpoint dots; when infection is heavy (esp. on Norway maple) significant chlorosis and premature defoliation can occur; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • usually not serious enough for chemical control except perhaps on Norway maple; fungicide sprays can be applied at budbreak and repeated 2-3 times at label intervals;	mancozeb mancozeb + copper hydroxide thiophanate-methyl
Verticillium Wilt *(Verticillium* spp.*)* p. 242	Flagging or wilting of individual limbs or portions of the canopy, usually in midsummer; leaves can be undersized and infected trees sometimes have heavy seed set; trees die slowly or suddenly, depending on the extent of infection and overall health of the tree; a distinctive olive-brown streaking may be evident in the wood of symptomatic branches or twigs; laboratory examination and culturing are usually required for definitive identification; particularly severe on Japanese and Norway maples in Connecticut in recent years; refer to fact sheet for more detailed information.	• prune and remove affected limbs as soon as symptoms are evident; • disinfest tools between cuts; • promote tree vigor; • avoid drought stress; • do not replant susceptible species in the area since the fungus is soilborne (refer to list of resistant species, Table 1).	No chemical control is suggested.

Aesculus (Buckeye, Horsechestnut)

Disease *(Pathogen/Cause)*	Diagnostic Symptoms	Management	Materials
Anthracnose *(Glomerella)* p. 114	Newly emerging shoots die and appear blighted in spring; irregular, brown areas can also develop on leaves; these necrotic areas are often defined by the leaf veins; some early-season defoliation may occur; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • prune infected twigs and branches when bark is dry; • maintain tree vigor; • chemical control is usually not necessary except for new transplants, young or specimen trees, or when defoliation has been heavy for several years; fungicides can be applied at budbreak and repeated as necessary according to label directions.	chlorothalonil chlorothalonil + thiophanate-methyl iprodione mancozeb mancozeb + copper hydroxide mancozeb + thiophanate-methyl thiophanate-methyl
Leaf Blotch *(Guignardia, Phyllosticta)* p. 40	Initial leaf symptoms appear as water-soaked areas of variable size; these patches turn reddish-brown and symptomatic leaves become quite brittle; when entire leaves and petioles become symptomatic, significant leaf drop can occur; pinpoint, black fruiting structures can be found in the necrotic areas; the presence of these structures helps to distinguish this disease from scorch due to abiotic stresses; symptoms usually don't appear until July and early defoliation usually starts in August.	• rake and remove fallen leaves; • some resistance is available (e.g., *Aesculus arguta*, *A. glabra* var. *sargentii*); • chemical control is usually not necessary; fungicides can be applied at budbreak and repeated for 2-4 applications according to label directions.	chlorothalonil chlorothalonil + iprodione chlorothalonil + thiophanate-methyl mancozeb mancozeb + copper hydroxide mancozeb + thiophanate-methyl

Aesculus (Buckeye, Horsechestnut) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Powdery Mildew *(Erysiphe)* p. 8	White to grayish, powdery growth on leaves, usually first evident on upper leaf surfaces but can occur on both surfaces of leaves; develops fairly late in the season; some premature fall coloration and leaf drop may occur; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • avoid excessive fertilization since tender, succulent leaves are more susceptible; • provide good air circulation around the tree; • spraying is usually not necessary since the disease has no significant impact on tree health; on specimen trees, fungicides can be applied as soon as symptoms are evident and repeated as necessary.	chlorothalonil + thiophanate-methyl fenarimol myclobutanil thiophanate-methyl triadimefon
Scorch *(Abiotic)* p. 492	Margins of leaves turn brown and curl; entire leaves develop a scorched appearance by late July or August; often associated with drought or heat; some premature leaf drop can occur; symptoms are very similar to leaf blotch but no fruiting structures are evident in symptomatic leaves.	• maintain tree vigor and water during periods of drought.	No chemical control is suggested.

Ailanthus (Tree-of-Heaven)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Armillaria Root Rot (*Armillaria* spp. *complex*) p. 326	Also called shoestring root rot and honey mushroom rot; this disease is difficult to identify since aboveground symptoms appear as general and progressive decline, which leads to the eventual death of trees; trees can die singly or in groups; trees under environmental or site-related stresses are particularly susceptible; diagnostic signs of the infection include black strands of the fungus called rhizomorphs (shoestrings) on the surface of the bark or at the base of infected trees, white fans of fungal growth with “mushroomy” odors under the bark, and the occasional growth of honey mushrooms at the base of infected trees in autumn; narrow, black lines are often evident in infected wood; the fungus can persist in stumps and large, woody roots for as long as 30 years.	• maintain tree vigor; • avoid any unnecessary stresses, esp. drought stress; • avoid planting susceptible trees in a site where this disease has been confirmed; • if replanting in the site, the stump and all woody roots greater than ½ inch in diameter should be removed.	No chemical control is suggested.
Verticillium Wilt (*Verticillium* spp.) p. 242	Flagging or wilting of individual limbs or portions of the canopy, usually in midsummer; leaves can be undersized and infected trees sometimes have heavy seed set; trees die slowly or suddenly, depending on the extent of infection and overall health of the tree; a distinctive brownish streaking may be evident in the wood of symptomatic branches or twigs; laboratory examination and culturing are usually required for definitive identification; refer to fact sheet for more detailed information.	• prune and remove affected limbs as soon as symptoms are evident; • disinfest tools between cuts; • promote tree vigor; • avoid drought stress; • do not replant susceptible species in the area since the fungus is soilborne (refer to list of resistant species, Table 1).	No chemical control is suggested.

Albizia (Mimosa, Silk-tree)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Mimosa Wilt *(Fusarium oxysporum* var. *perniciosum)* p. 248	Initial symptoms of this highly destructive disease usually develop in early to midsummer; leaves become chlorotic or olive-green and wilt; a distinctive feature is that they hang down from the twig; affected leaves eventually shrivel, dry, and drop; symptoms may first appear on one or two limbs but quickly spread to the entire tree; brown streaks are often evident in the sapwood of symptomatic limbs; tan, raised, or cushion-like fruiting structures of the fungus frequently develop at lenticels of symptomatic branches and are visible with a hand lens; most diseased trees die within one year after symptoms first appear.	• rogue and remove heavily infected trees to reduce the potential of spread to nearby trees; • promote tree vigor; • do not replant susceptible species in the area since the fungus can form resting structures that persist in the soil.	No chemical control is suggested.
Nectria Canker *(Nectria* spp.) p. 176	Random dieback of branches and limbs; usually associated with sunken cankers that are often covered with distinctive coral-colored or orange fruiting structures of the fungus; problematic on trees weakened by other factors such as drought.	• prune affected limbs back to healthy wood as soon as detected and when bark is dry; • avoid wounding; • maintain tree vigor.	No chemical control is suggested.

Amelanchier (Serviceberry, Shadblow)

Disease *(Pathogen/Cause)*	Diagnostic Symptoms	Management	Materials
Brown Rot *(Monilinia)* p. 76	Symptoms appear as a blossom blight characterized by a sudden collapse and browning of blossoms; shoot and twig blights can occur as the fungus grows from infected flowers into the wood; sunken, discolored cankers may persist on twigs or branches; fruit rot is a diagnostic symptom that is most obvious as fruit ripen; diagnostic signs are powdery, brownish-gray masses of fungal spores covering the surfaces of infected fruit and tissues; fruit mummies may persist on the tree into the winter; particularly problematic during the 2006 season.	• rake and remove infected fruit mummies and leaves; • prune dead or cankered twigs or branches; • on specimen trees, fungicide sprays can be applied at budbreak and continued according to label directions; critical sprays are early in the season, particularly during bloom.	myclobutanil thiophanate-methyl
Entomosporium Leaf Spot [Fabraea leaf spot] *(Diplocarpon mespili)* p. 78	Numerous small, reddish-brown spots appear on upper surfaces of leaves; as they increase in size, they frequently coalesce and result in significant mid-summer defoliation; infections of highly susceptible species develop twig and branch dieback if they are defoliated for several successive years.	• rake and remove fallen leaves; • maintain tree vigor; • provide good air circulation and avoid overhead irrigation; • for specimen trees, fungicides can be applied at budbreak and repeated 2-3 times as necessary according to label directions.	chlorothalonil chlorothalonil + iprodione chlorothalonil + thiophanate-methyl mancozeb mancozeb + thiophanate-methyl myclobutanil thiophanate-methyl

Amelanchier (Serviceberry, Shadblow) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Fire Blight *(Erwinia amylovora)* p. 376	Flowers wither and blacken; young twigs and branches die from the terminals back and appear as though "burned"; affected limbs frequently develop a characteristic shepherd's crook at the tip; dead leaves usually remain attached to the branch; sunken, discolored cankers may be evident on branches or the main trunk; this disease can result in tree death; refer to fact sheet for more detailed information.	• overwintering cankers should be pruned and removed during the winter; make cuts at least 10-12 inches below visible symptoms when bark is dry; • during the growing season, prune and remove infected branches as soon as they develop; make cuts at least 10-12 inches below visible symptoms when bark is dry; • carefully remove prunings to avoid spread; • disinfest tools between cuts; • avoid excessive nitrogen fertilization or vigor; • preventative copper sprays can be applied to the bark before growth emerges in spring; additional applications may be necessary to protect newly emerging shoots until flowering.	copper hydroxide copper sulphate pentahydrate mancozeb + copper hydroxide
Powdery Mildew *(Erysiphe, Phyllactinia, Podosphaera)* p. 8	White to grayish, powdery growth on leaves, usually first evident on upper leaf surfaces but can occur on both surfaces of leaves; develops fairly late in the season; some premature fall coloration and leaf drop may occur; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • avoid excessive fertilization since tender, succulent leaves are more susceptible; • provide good air circulation around the tree; • spraying is usually not necessary since the disease has no significant impact on tree health; on specimen trees, fungicides can be applied as soon as symptoms are evident and repeated as necessary.	copper sulphate pentahydrate myclobutanil propiconazole thiophanate-methyl triadimefon

Amelanchier (Serviceberry, Shadblow) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Rusts *(Gymnosporangium* spp.*)* p. 262	Several rust species attack this host and symptoms vary with species; diagnostic orangy-yellow spots form on leaves and severely infected leaves fall prematurely; other symptoms include swelling and distortion of petioles and twigs, often with a distinctive yellowish-orange coloration; severe infection may kill fruit and cause conspicuous leaf and shoot blight; these fungi require other hosts (*Juniperus* spp.) in order to complete their life cycles; refer to fact sheet for more detailed information;	• prune and remove infected branches or limbs; • if possible, eliminate the alternate hosts (any red cedar or juniper species) within a one-mile radius; • for specimen trees, fungicide sprays can be applied when new growth is emerging in spring and repeated 2-3 times at label intervals; this is usually when the gelatinous, orange telial horns are evident on the junipers (usually mid-May);	myclobutanil triadimefon

Berberis (Barberry)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Bacterial Leaf Spot *(Pseudomonas)* p.370	Infected leaves first develop irregular, water-soaked areas which gradually become purplish-brown; when tender, new shoots are infected, limited dieback may occur.	• avoid excessive nitrogen fertilization; • prune and remove affected twigs when the bark is dry and make cuts approx. 8-10 inches below symptoms; • disinfest tools between cuts.	No chemical control is suggested.
Phytophthora Root Rot *(Phytophthora* spp.*)* p. 354	General decline, poor growth and vigor due to root decay; leaves become chlorotic, droop, and brown; symptomatic plants may occur singly or in enlarging groups; can result in plant death; new transplants are highly sensitive; a distinctive cinnamon brown discoloration is sometimes visible in wood at the root/crown region; often associated with saturated soils or poor drainage.	• avoid excessive fertilization and planting in wet areas; • protectant fungicides can be applied to uninfected, asymptomatic plants adjacent to infected ones.	fosetyl-Al mefenoxam mono- and di- potassium salts of phosphorus acid phosphorous acid
Powdery Mildew *(Phyllactinia)* p. 8	White to grayish, powdery growth on leaves, usually first evident on upper leaf surfaces but can occur on both surfaces of leaves; develops fairly late in the season; some premature fall coloration and leaf drop may occur; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • avoid excessive fertilization since tender, succulent leaves are more susceptible; • provide good air circulation around the tree; • spraying is usually not necessary since the disease has no significant impact on tree health; on specimen trees, fungicides can be applied as soon as symptoms are evident and repeated as necessary	azoxystrobin copper sulphate pentahydrate myclobutanil thiophanate-methyl triadimefon

Betula **(Birch)**

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Anthracnose, Leaf Spots *(Marssoninia, Apiognomonia)* p. 82, 108	Brown spots with irregular, indistinct margins or brown to black margins develop on leaves; some premature defoliation may occur; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • provide good air circulation around the tree; • spraying is usually not necessary since these diseases have no significant impact on tree health; on specimen trees, fungicides can be applied at budbreak and repeated as necessary according to label directions.	copper sulphate pentahydrate mancozeb thiophanate-methyl
Armillaria Root Rot *(Armillaria* spp. *complex)* p. 326	Also called shoestring root rot and honey mushroom rot; this disease is difficult to identify since aboveground symptoms appear as general and progressive decline, which leads to the eventual death of trees; trees can die singly or in groups; trees under environmental or site-related stresses are particularly susceptible; diagnostic signs of the infection include black strands of the fungus called rhizomorphs (shoestrings) on the surface of the bark or at the base of infected trees, white fans of fungal growth with "mushroomy" odors under the bark, and the occasional growth of honey mushrooms at the base of infected trees in autumn; narrow, black lines are often evident in infected wood; the fungus can persist in stumps and large, woody roots for as long as 30 years.	• maintain tree vigor; • avoid any unnecessary stresses, esp. drought stress; • avoid planting susceptible trees in a site where this disease has been confirmed; • if replanting in the site, the stump and all woody roots greater than ½ inch in diameter should be removed.	No chemical control is suggested.

Betula (Birch) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Leaf Blister *(Taphrina carnea)* p. 4	Pale-green spots ¼ - ¾ inch in diameter appear on newly expanding leaves; spots expand and develop into blister-like bulges on the leaves; as the blisters age they become necrotic; trees with heavy infections usually appear off-colored since the symptomatic leaves remain attached to the tree.	• maintain vigor; • spraying is usually not necessary; however, on specimen or newly transplanted trees, fungicide sprays can be applied before buds begin to swell in spring.	chlorothalonil chlorothalonil + iprodione chlorothalonil + thiophanate-methyl mancozeb
Leaf Rust *(Melampsorium betulinum)* p. 274	Symptoms usually appear in late summer as bright, yellowish-orange pustules on the undersides of leaves; chlorotic areas develop on upper leaf surfaces and may be so prevalent that they coalesce to form large, necrotic patches; leaves often drop prematurely; larch is the alternate host but is not necessary for the disease cycle; dwarf, gray, paper, swamp, European white, and yellow birch are susceptible.	• rake and remove fallen leaves; • some resistance is available (e.g., Japanese white birch, sweet birch, *B. utilis*, *B. ernami*); • spraying is usually not necessary since the disease has no significant impact on tree health; on specimen trees, fungicides can be applied at budbreak and repeated as necessary according to label directions.	azoxystrobin copper sulphate pentahydrate mancozeb mancozeb + copper hydroxide myclobutanil triadimefon
Perennial Canker *(Neonectria galligena)* p. 182	Irregular swellings and cracks develop on branches or the main trunk; these are frequently associated with branch forks; thick callus rolls or rings are sometimes evident at the margins; cankered areas are weak and prone to breakage; black, paper, and yellow birch are highly susceptible.	• maintain tree vigor; • prune and remove cankered branches back to healthy wood when bark is dry; • avoid unnecessary wounds or injuries.	No chemical control is suggested.

Betula (Birch) cont'd

Disease *(Pathogen/Cause)*	Diagnostic Symptoms	Management	Materials
Powdery Mildew *(Erysiphe)* p. 8	White to grayish, powdery growth on leaves, usually first evident on upper leaf surfaces but can occur on both surfaces of leaves; develops fairly late in the season; some premature fall coloration and leaf drop may occur; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • avoid excessive fertilization since tender, succulent leaves are more susceptible; • provide good air circulation around the tree; • spraying is usually not necessary since the disease has no significant impact on tree health; on specimen trees, fungicides can be applied as soon as symptoms are evident and repeated as necessary.	azoxystrobin copper sulphate pentahydrate thiophanate-methyl triadimefon

Buxus (Boxwood)

Disease (*Pathogen/Cause*)	Diagnostic Symptoms	Management	Materials
Boxwood Blight (*Calonectria pseudonaviculata)*	This emerged as a highly destructive disease new to North America in October 2011; plants develop leaf spots and zonate lesions; leaves turn straw-colored; distinctive, diagnostic dark brown to black stem lesions develop of shoots of any age; disease usually results in severe defoliation, dieback, disfigurement, and plant death; all *Buxus* species are susceptible; *B. sempervirens* 'Suffruticosa' (English boxwood) and *B. sempervirens* (American or common boxwood) are highly susceptible; can be confused with Voltella blight and canker and Macrophome leaf spot; refer to fact sheet and best management practices for more detailed information.	• scout for symptoms and submit suspicious samples for diagnosis; • if disease is confirmed, remove infected plants following guidelines and "Best Management Practices;" • fungicides can be applied as protectants when new growth emerges in the spring and repeated at label intervals as necessary.	azoxystrobin chlorothalonil mancozeb propiconazole
Canker and Leaf Blight [Volutella Blight and Canker] (*Pseudonectria rousseliana [Volutella buxi])*	First symptoms of this common disease of boxwood are evident in spring; individual shoots or entire plants exhibit poor growth; leaves of affected limbs turn from green to a distinctive straw-tan color; salmon-colored, waxy pustules of the fungus develop on infected leaves and stems and are readily visible with a hand lens; bark may be loose and readily peel to reveal gray or black discolored wood; extensive dieback and leaf drop can occur; often more problematic on plants under stress.	• prune and remove dead branches as soon as evident when bark is dry; • any fallen leaves or those that have lodged in crotches or branches should be removed-vacuuming can be effective; • avoid winter injury and other stresses; • fungicides can be applied when new growth emerges in the spring and repeated at label intervals as necessary.	chlorothalonil *copper hydroxide copper sulfate copper sulphate pentahydrate mancozeb

Buxus (Boxwood) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Fungal Leaf Spots *(Macrophoma, Phyllosticta, Fusarium)*	Leaves turn yellow or straw-colored; diagnostic fruiting structures of the fungus appear as small, black dots on the symptomatic leaves; extensive leaf drop can occur; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • provide good air circulation and avoid overhead irrigation; • spraying is usually not necessary since the disease has no significant impact on plant health; on specimen plants, fungicides can be applied as new growth emerges in spring and repeated as necessary;	chlorothalonil copper hydroxide mancozeb *potassium bicarbonate
Phytophthora Root Rot *(Phytophthora* spp.*)* p. 354	Foliage has poor color and becomes tan and desiccated; plants have poor vigor and show general, progressive decline symptoms due to root decay; individual sections of the plant may be symptomatic in an otherwise healthy canopy; symptomatic plants may occur singly or in enlarging groups; can result in plant death; a distinctive brown discoloration is sometimes visible in wood at the root/crown region; often associated with water-logged soils; all boxwoods are susceptible;	• avoid excessive fertilization and planting in wet areas; • protectant fungicides can be applied to uninfected, asymptomatic plants adjacent to infected plants;	fosetyl-Al mefenoxam mono- and di-potassium salts of phosphorus acid phosphorous acid

Buxus (Boxwood) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Root Nematodes *(Meloidogyne, Pratylenchus)* p. 432	Plants undergo progressive decline; symptoms include stunting, wilting, loss of vigor, and chlorosis; bronzing of internal foliage is common; depending upon the nematode, root symptoms include formation of swollen galls or lesions; disease severity is influenced by nematode populations and other environmental factors that impair root function such as drought; diagnosis requires soil samples from the vicinity of symptomatic plants.	• maintain plant vigor and avoid stress.	No chemical control is suggested.
Winter Injury/Sunscald *(Abiotic)* p. 492	Damage to the cambium and sapwood from freezing and sunscalding results in dieback of leaves, twigs, and even entire plants; leaves develop a brown to reddish-brown, bronze color; bark splitting and peeling on stems and branches is common and may also result in dieback; refer to fact sheet for more detailed information.	• maintain vigor; • avoid late-season or excessive fertilization; • prune and remove symptomatic branches or limbs; • provide appropriate winter protection in exposed areas or in areas that are subject to extreme temperature fluctuations during winter.	No chemical control is suggested.

Carpinus (Hornbeam, Blue Beech)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Anthracnose *(Apiosporopsis)* p. 112	Irregular, brown to reddish-brown (often papery) areas develop along and sometimes between veins and at leaf margins; symptoms are very similar to those associated with drought and heat stress; some defoliation may occur when infection is heavy; occasional tip dieback; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • prune dead twigs and branches; • chemical control is usually not necessary except for new transplants, young or specimen trees, or when defoliation has been heavy for several years; fungicide sprays can be applied at budbreak and repeated 2-3 times at label intervals.	azoxystrobin chlorothalonil chlorothalonil + thiophanate- methyl *copper hydroxide copper sulfate mancozeb mancozeb + copper hydroxide mancozeb + thiophanate-methyl thiophanate-methyl
Botryosphaeria Canker *(Botryosphaeria)* p. 120	Random dieback of branches and limbs; usually associated with sunken cankers in which black fruiting structures of the fungus may be visible; problematic on trees weakened by other factors such as drought.	• prune affected limbs back to healthy wood as soon as detected and when bark is dry; • avoid wounding; • maintain tree vigor; • avoid unnecessary stresses, esp. drought stress.	No chemical control is suggested.
Nectria Canker *(Neonectria galligena)* p. 182	Irregular swellings and cracks develop on branches or the main trunk; these are frequently associated with branch forks, and/or branch scars or stubs; thick callus rolls or rings are sometimes evident at the margins; cankered areas are weak and prone to storm breakage.	• maintain tree vigor; • prune and remove cankered branches back to healthy wood when bark is dry; • avoid unnecessary wounds or injuries.	No chemical control is suggested.

Carya (Hickory)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Anthracnose *(Glomerella)* p. 114	Symptoms usually don't appear until late summer or early autumn; irregular, brown spots with yellow indefinite edges develop on leaves; when spots are numerous, they coalesce and entire leaves turn brown, curl, and drop prematurely; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • usually not serious enough for chemical control since defoliation occurs late in the season; • on specimen trees, fungicides can be applied at budbreak and repeated 2-3 times at label intervals.	mancozeb mancozeb + copper hydroxide thiophanate-methyl
Canker *(Nectria* and *Neonectria* spp.) p. 176	Irregular swellings and cracks develop on branches or the main trunk; these are frequently associated with branch forks, and/or branch scars or stubs; thick callus rolls or rings are sometimes evident at the margins; cankered areas are weak and prone to storm breakage.	• maintain tree vigor; • prune and remove cankered branches back to healthy wood when bark is dry; • avoid unnecessary wounds or injuries.	No chemical control is suggested.
Microstroma Leaf Spot and Witches'-Broom *(Microstroma juglandis)* p. 252	Yellow lesions with indefinite margins develop on the upper surfaces of leaflets; distinct patches of white fruting structures of the fungus are visible on corresponding areas on the under surfaces of the leaflets; this fungus has also been associated with the presence of witches'-brooms on infected trees.	• rake and remove fallen leaves; • usually not serious enough for chemical control since defoliation occurs late in the season; • on specimen trees, fungicides can be applied at budbreak and repeated 2-3 times at label intervals.	mancozeb + copper hydroixide

Carya (Hickory) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Powdery Mildew *(Erysiphe)* p. 8	White to grayish, powdery growth on leaves, usually first evident on upper leaf surfaces but can occur on both surfaces of leaves; develops fairly late in the season; some premature fall coloration and leaf drop may occur; refer to fact shee for more detailed information.	• rake and remove fallen leaves; • avoid excessive fertilization since tender, succulent leaves are more susceptible; • provide good air circulation around the tree; • spraying is usually not necessary since the disease has no significant impact on tree health; on specimen trees, fungicides can be applied as soon as symptoms are evident and repeated as necessary.	chlorothalonil + thiophanate-methyl myclobutanil thiophanate-methyl triadimefon

Castanea (Chestnut)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Blight *(Cryphonectria parasitica)* p. 160	This highly destructive disease has almost eliminated chestnuts in most of the United States; symptoms include twig and branch blights and girdling cankers on the main trunk; cankers vary in appearance and can appear as slightly sunken or swollen areas or as spindle-shaped or elongate swellings; reddish-orange fruiting structures of the fungus can occasionally be seen in the cankered areas; since the fungus does not infect the roots, numerous sprouts can often be found around old stumps; American chestnuts are most susceptible followed by European chestnuts; Japanese, Chinese, and hybrid chestnuts have varying levels of resistance.	• prune and remove affected limbs as soon as symptoms are evident; cuts should be made several inches below visible symptoms; • disinfest tools between cuts; • promote tree vigor; • resistant hybrids and varieties of trees are available.	No chemical control is suggested.

Catalpa (Catalpa)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Fungal Leaf Spots *(Phyllosticta, Alternaria, Cercospora)* p. 74, 84	Irregular to circular, brown spots develop on leaves; the size, shape, and color vary with the causal agent; some premature defoliation can occur; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • provide good air circulation around the tree; • spraying is usually not necessary since the disease has no significant impact on tree health; on specimen trees, fungicides can be applied at budbreak and repeated as necessary according to label directions.	azoxystrobin mancozeb mancozeb + copper hydroxide myclobutanil thiophanate-methyl
Powdery Mildew *(Erysiphe)* p. 8	White to grayish, powdery growth on leaves, usually first evident on upper leaf surfaces but can occur on both surfaces of leaves; develops fairly late in the season; some premature fall coloration and leaf drop may occur.	• rake and remove fallen leaves; • avoid excessive fertilization since tender, succulent leaves are more susceptible; • provide good air circulation around the tree; • spraying is usually not necessary since the disease has no significant impact on tree health; on specimen trees, fungicides can be applied as soon as symptoms are evident and repeated as necessary.	chlorothalonil + thiophanate-methyl myclobutanil thiophanate-methyl
Verticillium Wilt *(Verticillium* spp.*)* p. 242	Flagging or wilting of individual limbs or portions of the canopy, usually in midsummer; leaves can be undersized; trees die slowly or suddenly, depending on the extent of infection and overall health of the tree; a distinctive brown streaking may be evident in the wood of symptomatic branches or twigs; laboratory examination and culturing are usually required for definitive identification; especially problematic on street trees; refer to fact sheet for more detailed information.	• prune and remove affected limbs as soon as symptoms are evident; • disinfest tools between cuts; • promote tree vigor; • avoid drought stress; • do not replant susceptible species in the area since the fungus is soilborne (refer to list of resistant species, Table 1).	No chemical control is suggested.

Cedrus (Atlas Cedar, Deodar Cedar)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Armillaria Root Rot (*Armillaria* spp. *complex*) p. 326	Also called shoestring root rot and honey mushroom rot; this disease is difficult to identify since aboveground symptoms appear as general and progressive decline that leads to the eventual death of trees; trees can die singly or in groups; trees under environmental or site-related stresses are particularly susceptible; on conifers, excessive resin production at points of infections or at the bases of trees can be important symptoms of infection; the diagnostic black strands of the fungus called rhizomorphs (shoestrings) are usually not present on conifers; signs of the infection includes white fans of fungal growth with "mushroomy" odors under the bark and the occasional growth of honey mushrooms at the base of infected trees in autumn; the fungus can persist in stumps and large, woody roots for as long as 30 years.	• maintain tree vigor; • avoid any unnecessary stresses, esp. drought stress; • avoid planting susceptible trees in a site where this disease has been confirmed; • if replanting in the site, the stump and all woody roots greater than ½ inch in diameter should be removed.	No chemical control is suggested.

Cedrus (Atlas Cedar, Deodar Cedar) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Diplodia Blight [Sphaeropsis Tip Blight] (*Diplodia pinea)* p. 130	Tip blight results from infection of newly emerging buds and shoots; infected buds or shoots usually stop growing before or during needle elongation and needles are frequently stunted and short; infected tissues are straw-colored and have excessive resin flow; usually kills only current-season buds and shoots and second-year cones, but can cause significant dieback on stressed trees; black fruiting structures of the fungus may be visible at the base of needles and on cones; symptoms may be distributed uniformly throughout the canopy or concentrated in lower branches; drought-stressed trees are particularly susceptible; refer to fact sheet for more detailed information.	• prune and remove blighted twigs, branches, and cones during dry weather in autumn; • maintain tree vigor; special attention should be given to watering during periods of drought; • fungicide sprays can be applied at budbreak and repeated 2-3 times at label intervals.	chlorothalonil + thiophanate-methyl copper hydroxide copper sulphate pentahydrate mancozeb mancozeb + copper hydroxide *potassium bicarbonate propiconazole thiophanate-methyl triadimefon
Phomopsis Blight *(Phomopsis juniperivora)* p. 146	Tips and whole sections of branches progressively die and turn brown; affected needles usually remain attached to the branches; symptoms are frequently uniformly distributed over the shrub and are most obvious in spring or early summer; immature or newly expanding needles are most susceptible; upon close inspection, black fruiting bodies are visible in browned tissues; refer to fact sheet for more detailed information.	• prune and remove infected twigs and branches; • avoid overhead irrigation and excessive crowding; • severely infected plants should be rogued and removed; • maintain vigor; • fungicide sprays can be applied as new growth emerges in spring and repeated at label intervals until growth is fully expanded and mature.	chlorothalonil mancozeb mancozeb + copper hydroxide thiophanate-methyl

Cedrus (Atlas Cedar, Deodar Cedar) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Winter Dieback *(Abiotic)* p. 492	Portions of the tree may discolor and fail to develop when growth resumes in spring; in severe cases, entire trees may die; this species often has problems with winter hardiness associated with extended periods of extremely cold temperatures; refer to fact sheet for more detailed information.	• avoid stress; • maintain vigor and pay attention to planting site.	No chemical control is suggested.

Celtis (Hackberry)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Fungal Leaf Spots *(Phyllosticta, Cercosporella)* p. 84	Circular or irregular, necrotic spots develop on leaves and are frequently uniformly distributed over the surface of the leaf; some early leaf drop can occur when infection is heavy; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • provide good air circulation around the tree; • avoid overhead irrigation of small trees; • spraying is usually not necessary since the disease has no significant impact on tree health; on specimen trees, fungicides can be applied when new growth emerges and repeated as necessary according to label directions.	chlorothalonil mancozeb myclobutanil thiophanate-methyl triadimefon
Powdery Mildew *(Erysiphe, Podosphaera)* p. 8	White to grayish, powdery growth on leaves, usually first evident on upper leaf surfaces but can occur on both surfaces of leaves; develops fairly late in the season; some premature fall coloration and leaf drop may occur; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • avoid excessive fertilization since tender, succulent leaves are more susceptible; • provide good air circulation around the tree; • spraying is usually not necessary since the disease has no significant impact on tree health; on specimen trees, fungicides can be applied as soon as symptoms are evident and repeated as necessary.	copper sulphate pentahydrate myclobutanil thiophanate-methyl triadimefon
Witches' Broom *(Podosphaera and Eriophyid mite)* p. 14	Witches' brooms occur when many short twigs develop in close proximity at a conspicuous swelling or knot on the branch; brooms can be quite numerous and distributed throughout the canopy.	• trees appear to bear many brooms without any obvious loss of vigor; • unsightly trees can be removed; • no controls are effective.	No chemical control is suggested.

Cercidiphyllum (Katsura-tree)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Armillaria Root Rot *(Armillaria* spp. *complex)* p. 326	Also called shoestring root rot and honey mushroom rot; this disease is difficult to identify since aboveground symptoms appear as general and progressive decline that leads to the eventual death of trees; trees can die singly or in groups; trees under environmental or site-related stresses are particularly susceptible; diagnostic signs of the infection include black strands of the fungus called rhizomorphs (shoestrings) on the surface of the bark or at the base of infected trees, white fans of fungal growth with "mushroomy" odors under the bark, and the occasional growth of honey mushrooms at the base of infected trees in autumn; narrow, black lines are often evident in infected wood; the fungus can persist in stumps and large, woody roots for as long as 30 years.	• maintain tree vigor; • avoid any unnecessary stresses, esp. drought stress; • avoid planting susceptible trees in a site where this disease has been confirmed; • if replanting in the site, the stump and all woody roots greater than ½ inch in diameter should be removed.	No chemical control is suggested.
Botryosphaeria Canker *(Botryosphaeria)* p. 120	Random dieback of branches and limbs; usually associated with sunken cankers in which black fruiting structures of the fungus may be visible; problematic on trees weakened by other factors such as drought.	• prune affected limbs back to healthy wood as soon as detected and when bark is dry; • avoid wounding; • maintain tree vigor; • minimize unnecessary stresses, esp. drought stress.	No chemical control is suggested.

Cercidiphyllum (Katsura-tree) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Verticillium Wilt *(Verticillium* spp.*)* p. 242	Flagging or wilting of individual limbs or portions of the canopy, usually in midsummer; leaves can be undersized; trees die slowly or suddenly, depending on the extent of infection and overall health of the tree; a distinctive olive or brown streaking may be evident in the wood of symptomatic branches or twigs; laboratory examination and culturing are usually required for definitive identification; refer to fact sheet for more detailed information.	• prune and remove affected limbs as soon as symptoms are evident; • disinfest tools between cuts; • promote tree vigor; • avoid drought stress; • do not replant susceptible species in the area since the fungus is soilborne (refer to list of resistant species, Table 1).	No chemical control is suggested.

Cercis (Redbud)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Anthracnose (unknown) p.108	Initial symptoms include necrotic lesions that usually follow the veins or leaf margins; these expand into large brown blotches; can result in pre-mature leaf drop; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • spraying is usually not necessary since the disease has no significant impact on tree health; on specimen trees, fungicides can be applied as new growth emerges and repeated as necessary according to label directions.	azoxystrobin chlorothalonil chlorothalonil + thiophanate-methyl copper sulphate pentahydrate mancozeb mancozeb + copper hydroxide mancozeb + thiophanate-methyl thiophanate-methyl
Canker and Dieback (*Botryosphaeria*) p. 120	Cankers begin as small, sunken areas on branches; these areas gradually increase in size and the bark in the center blackens and cracks; the most obvious symptom is a flag or a branch on which the foliage dries out and turns orangy-brown; leaves wilt and branches die as the cankers girdle the stem; the most prevalent disease of redbud in the landscape.	• prune and remove infected branches well below cankered areas when the bark is dry; • severely infected trees should be rogued and removed; • maintain tree vigor and avoid insect and mechanical injuries.	No chemical control is suggested.
Fungal Leaf Spots *(Mycosphaerella, Phyllosticta)* p. 44	Lesions develop as irregular to circular areas on leaves; when infection is severe, spots coalesce and premature defoliation can occur; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • spraying is usually not necessary since the disease has no significant impact on tree health; on specimen trees, fungicides can be applied as new growth emerges and repeated as necessary according to label directions.	azoxystrobin mancozeb mancozeb + copper hydroxide propiconazole thiophanate-methyl

Cercis (Redbud) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Verticillium Wilt *(Verticillium* spp.*)* p. 242	Flagging or wilting of individual limbs or portions of the canopy, usually in midsummer; leaves can be undersized; trees die slowly or suddenly, depending on the extent of infection and overall health of the tree; a distinctive brown streaking may be evident in the wood of symptomatic branches or twigs; laboratory examination and culturing are usually required for definitive identification; refer to fact sheet for more detailed information.	• prune and remove affected limbs as soon as symptoms are evident; • disinfest tools between cuts; • promote tree vigor; • avoid drought stress; • do not replant susceptible species in the area since the fungus is soilborne (refer to list of resistant species, Table 1).	No chemical control is suggested.

Chaenomeles (Quince)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Canker and Dieback (*Botryosphaeria* spp) p. 120	Cankers begin as small, sunken areas on branches; these areas gradually increase in size and the bark in the center blackens and cracks; the most obvious symptom is a flag or a branch on which the foliage dries out and turns orangy-brown; leaves wilt and branches die as the cankers girdle the stem.	• prune and remove infected branches well below cankered areas; • severely infected trees should be rogued and removed; • maintain tree vigor and avoid insect and mechanical injuries.	No chemical control is suggested.
Fire Blight *(Erwinia amylovora)* p. 376	Flowers wither and blacken; young twigs and branches die from the terminals back and appear as though "burned"; affected limbs frequently develop characteristic shepherd's crooks at the tips; dead leaves usually remain attached to the branch; sunken, discolored cankers may be evident on branches or the main trunk; symptoms often develop in a relatively short period of time; refer to fact sheet for more detailed information.	• overwintering cankers should be pruned and removed during the winter; make cuts at least 10-12 inches below visible symptoms when bark is dry; • during the growing season, prune and remove infected branches as soon as they develop; make cuts at least 10-12 inches below visible symptoms when bark is dry; • carefully remove prunings to avoid spread; • disinfest tools between cuts; • avoid excessive nitrogen fertilization or vigor; • preventative copper sprays can be applied to the bark before growth emerges in spring; additional applications may be necessary to protect newly emerging shoots until flowering.	copper hydroxide copper sulphate pentahydrate mancozeb + copper hydroxide

Chaenomeles (Quince) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Leaf Spot *(Diplocarpon mespili)* p. 78	Discrete, circular, dark-brown spots develop on leaves; when numerous, they coalesce and form large, dead blotches; fruiting structures of the fungus develop under the cuticle of lesions and give the spots a blister-like appearance; significant early leaf drop can occur; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • provide good air circulation around the tree and avoid overhead watering; • spraying is usually not necessary since the disease has no significant impact on tree health; on specimen trees, fungicides can be applied when new growth emerges and repeated as necessary according to label directions.	chlorothalonil chlorothalonil + thiophanate-methyl mancozeb myclobutanil thiophanate-methyl
Rusts *(Gymnosporangium* spp.*)* p. 262	Several species of rust fungi attack quince and symptoms vary with species; diagnostic orangy-yellow spots form on leaves and severely affected leaves fall prematurely; other symptoms include swelling and distortion of petioles and twigs; severe infection may kill fruit and cause conspicuous leaf and shoot blights; these fungi require other hosts (*Juniperus* spp.) in order to complete their life cycles; refer to fact sheet for more detailed information.	• prune and remove infected branches or limbs; • for specimen trees, eliminate the alternate hosts (any red cedar or juniper species) within a one-mile radius, if possible; • fungicide sprays can be applied when new growth is emerging in spring; this is usually when the gelatinous, orange telial horns are visible on the junipers (usually mid-May); sprays are repeated as necessary at label intervals.	chlorothalonil + iprodione mancozeb myclobutanil

Chamaecyparis (False Cypress, White Cedar)

Disease *(Pathogen/Cause)*	Diagnostic Symptoms	Management	Materials
Blight *(Phomopsis)* p. 146	Branch tips turn brown and progressively die back; needles on infected branches usually persist on the tree; small, black fruiting structures may be evident at the base of dead tissues; symptoms are especially pronounced in late winter and early spring.	• prune and remove infected twigs and branches when bark is dry; • avoid overhead irrigation and crowding; • resistant varieties are available (e.g., *C. pisifera* 'Plumosa Aurea,' 'Filifera'); • fungicide sprays can be applied when new growth appears in the spring and continued at label intervals until tissues are fully elongated and mature.	azoxystrobin thiophanate-methyl thiophanate-methyl + mancozeb
Needle and Tip Blight *(Pestalotiopsis)* p. 190	Affected needles and shoots are characterized by progressive yellowing and browning that begins at the tips and moves toward the base of the needles; shoots wilt and brown as the fungus causes girdling cankers in succulent tissues; usually more problematic on weak trees.	• maintain vigor; • avoid unnecessary stress; • prune and remove infected twigs when bark is dry.	No chemical control is suggested.
Phytophthora Root Rot *(Phytophthora* spp.*)* p. 354	General decline, poor growth and vigor due to root decay; needles become chlorotic, droop, and brown; symptomatic trees may occur singly or in enlarging groups; can result in tree death; excessive resin is sometimes visible on the outer bark at the base of the tree; a diagnostic brown discoloration may be evident on the inner bark and cambium at the root/crown area; frequently more serious on trees in sites where excess water is a persistent problem (e.g., clay soils, low areas); seedlings are highly sensitive.	• avoid excessive fertilization and planting in wet areas; • no fungicides are curative; protectant fungicides can be applied to uninfected, asymptomatic trees adjacent to infected trees.	fosetyl-Al mefenoxam mono- and di- potassium salts of phosphorus acid phosphorous acid

Chamaecyparis (False Cypress, White Cedar) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Tip Blight *(Abiotic)*	Tip and branch dieback, with symptoms similar to those associated with Phomopsis blight (without fungal fruiting structures).	• prune affected branches back to healthy wood to minimize secondary invaders or opportunistic pests; • avoid wounds and stresses; • maintain vigor.	No chemical control is suggested.

Cladrastis (Yellowwood)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Botryosphaeria Canker *(Botryosphaeria spp.)* p. 120	Random dieback of branches and limbs; usually associated with sunken cankers in which black fruiting structures of the fungus may be visible; problematic on trees weakened by other factors such as drought.	• prune affected limbs back to healthy wood as soon as detected and when bark is dry; • avoid wounding and other unnecessary stresses, esp. drought stress; • maintain tree vigor.	No chemical control is suggested.
Powdery Mildew *(unknown)* p. 8	White to grayish, powdery growth on leaves, usually first evident on upper leaf surfaces but can occur on both surfaces of leaves; develops fairly late in the season; some premature fall coloration and leaf drop may occur; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • avoid excessive fertilization since tender, succulent leaves are more susceptible; • provide good air circulation around the tree; • spraying is usually not necessary since the disease has no significant impact on tree health; on specimen trees, fungicides can be applied as soon as symptoms are evident and repeated as necessary.	thiophanate-methyl
Verticillium Wilt *(Verticillium spp.)* p. 242	Flagging or wilting of individual limbs or portions of the canopy, usually in midsummer; leaves can be undersized and infected trees sometimes have heavy seed set; trees die slowly or suddenly, depending on the extent of infection and overall health of the tree; a distinctive brown discoloration or streaking may be evident in the wood of symptomatic branches or twigs; laboratory examination and culturing are usually required for definitive identification; refer to fact sheet for more detailed information.	• prune and remove affected limbs as soon as symptoms are evident; • disinfest tools between cuts; • promote tree vigor; • avoid drought stress; • do not replant susceptible species in the area since the fungus is soilborne (refer to list of resistant species, Table 1).	No chemical control is suggested.

Cornus (Dogwood)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Anthracnose *(Discula destructiva)* p. 106	This is considered the most serious disease of dogwood in Connecticut and the eastern seaboard; it has resulted in the death of many dogwoods throughout its native range; initial symptoms include brown spots up to ¼ inch in diameter that can be seen on both leaf surfaces; spots frequently develop distinctive purplish-brown margins and pinpoint, black fruiting structures can be seen in the centers of the lesions; spots may be so numerous that they coalesce, resulting in large, necrotic sections on the leaves; a diagnostic symptom is the persistence of infected, necrotic leaves that hang on the tree throughout the winter; these leaves serve as a source of fungal spores in spring; reddish-brown spots may also develop on flower bracts; sunken, discolored cankers can develop on twigs, branches, and the main trunk; symptoms and branch dieback typically begin on the lower limbs and move progressively up the tree; these result in branch dieback or whole tree death when the main trunk is girdled; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • prune and remove cankered limbs and dead wood; • maintain tree vigor; • provide adequate spacing for good air circulation; • control insects and avoid unnecessary mechanical injuries; avoid soil compaction; • resistant species are available (*Cornus kousa*, *C. florida* X *C. kousa* hybrids, 'Stellar' series); • fungicide applications can be made at budbreak, when bracts fall, and 4 weeks later; a late-summer fungicide application is also necessary when fruit and leaves begin to color.	azoxystrobin chlorothalonil chlorothalonil + thiophanate-methyl *copper hydroxide copper sulphate pentahydrate mancozeb mancozeb + copper hydroxide mancozeb + thiophanate-methyl *potassium bicarbonate propiconazole thiophanate-methyl

Cornus (Dogwood) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Armillaria Root Rot *(Armillaria* spp. *complex)* p. 326	Also called shoestring root rot and honey mushroom rot; this disease is difficult to identify since aboveground symptoms appear as general and progressive decline that leads to the eventual death of trees; trees can die singly or in groups; trees under environmental or site-related stresses are particularly susceptible; diagnostic signs of the infection include black strands of the fungus called rhizomorphs (shoestrings) on the surface of the bark or at the base of infected trees, white fans of fungal growth with "mushroomy" odors under the bark, and the occasional growth of honey mushrooms at the base of infected trees in autumn; narrow, black lines are often evident in infected wood; the fungus can persist in stumps and large, woody roots for as long as 30 years.	• maintain tree vigor; • avoid any unnecessary stresses, esp. drought stress; • avoid planting susceptible trees in a site where this disease has been confirmed; • if replanting in the site, the stump and all woody roots greater than ½ inch in diameter should be removed.	No chemical control is suggested.

Cornus (Dogwood) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Botrytis Blight *(Botrytis cinerea)* p. 72	Irregular, necrotic patches develop on flower bracts and leaves in wet weather; lesions expand and disease spreads when senescing bracts fall on asymptomatic leaves; infected tissues are frequently covered with a distinctive grayish-brown, fuzzy mass of fungal growth that gives this disease the common name "gray mold."	• rake and remove fallen leaves; • maintain tree vigor; • IF conditions are wet during bloom, preventative fungicides can be applied at budbreak and repeated as necessary during the season according to label directions.	chlorothalonil chlorothalonil + thiophanate-methyl copper sulphate pentahydrate mancozeb mancozeb + copper hydroxide mancozeb + thiophanate-methyl *potassium bicarbonate thiophanate-methyl
Crown Canker *(Phytophthora cactorum)* p. 358	Infected trees have poor vigor, small leaves with pale color, and often exhibit premature fall coloration; progressive dieback of twigs and branches may occur as basal cankers enlarge and girdle the tree; cankers appear as discolored, sunken areas that are often visible near the base of the tree; some bleeding of reddish-brown fluid can occur in affected areas of the trunk.	• maintain tree vigor by attention to irrigation, soil compaction; • mildly infected trees have occasionally been reported to recover; • rogue and remove heavily infected trees to reduce the potential of spread to nearby trees; • recent studies have demonstrated preliminary success with directed basal bark sprays or injections of mono- and di-potassium salts of phosphorus acid.	mono- and di-potassium salts of phosphorus acid phosphorus acid

Cornus (Dogwood) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Powdery Mildew *(Erysiphe)* p. 8	Leaves appear distinctively purple or reddish-brown in mid- to late summer; diffuse lesions can also develop on upper leaf surfaces; this is usually followed by the typical whitish-gray, thin, superficial, powdery growth of the fungus; symptoms usually appear late in the season and can result in some premature defoliation; recent reports suggest that this disease has a greater impact on tree health and vigor than previously suggested; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • provide good air circulation around the tree; • spraying is usually not necessary; however, recent reports indicate that sprays may be helpful; fungicides can be applied as soon as symptoms are evident and repeated at label intervals as necessary.	azoxystrobin chlorothalonil + thiophanate-methyl copper sulphate pentahydrate fenarimol myclobutanil *potassium bicarbonate propiconazole *sulfur thiophanate-methyl triadimefon
Scorch *(Abiotic)* p. 492	Margins and tips of leaves turn brown and occasionally roll upward; symptoms usually appear in mid- or late summer; some premature leaf drop may occur.	• avoid plant stress, especially drought stress; • promote tree vigor and pay attention to planting site; • avoid soil compaction.	No chemical control is suggested.

Cornus (Dogwood) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Spot Anthracnose *(Elsinoe corni)* p. 18	Very small, purplish-red spots with distinct margins no more than 1/10 inch in diameter develop on flower bracts, leaves, petioles, fruit, peduncles, and green twigs; centers sometimes have a tan coloration and can drop out; can result in some distortion of the leaves and in premature defoliation; repeated defoliation can weaken trees.	• rake and remove fallen leaves; • provide good air circulation around the tree; • spraying is usually not necessary since the disease has no significant impact on tree health; on specimen trees, fungicides can be applied at budbreak and repeated as necessary according to label directions.	azoxystrobin chlorothalonil chlorothalonil + thiophanate-methyl copper hydroxide mancozeb mancozeb + copper hydroxide mancozeb + thiophanate-methyl myclobutanil *potassium bicarbonate thiophanate-methyl triadimefon
Tip Blight *(Botryosphaeria)* p. 120	Dieback of twigs and small branches is associated with sunken, discolored, girdling cankers; black, pimple-like, fungal fruiting structures may be visible in the canker; disease is more problematic on trees stressed by site or environmental factors.	• prune and remove symptomatic twigs and branches; • maintain tree vigor; • avoid unnecessary stresses, esp. drought stress.	No chemical control is suggested.

Corylus (Contorted Walking Stick, Filbert, Hazelnut)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Eastern Filbert Blight (Twig Blight/Canker) *(Anisogramma anomola)* p. 158	Progressive dieback of twigs, branches, and limbs; a diagnostic symptom develops on infected or dead twigs or branches and appears as distinctive rows of longitudinal splits that contain black fruiting structures of the fungus; this symptom is often confused with egg-laying scars of cicadas; can be an extremely destructive disease.	• prune and remove affected twigs and branches below symptomatic portions when bark is dry; • rogue and remove heavily infected plants; • maintain tree vigor; • chemical control may not be effective or practical in many landscape situations; • if nuts are harvested for consumption, check the fungicide label.	chlorothalonil copper hydroxide fenarimol propiconazole
Powdery Mildew *(Erysiphe)* p. 8	White to grayish, powdery growth on leaves, usually first evident on upper leaf surfaces but can occur on both surfaces of leaves; develops fairly late in the season; some premature fall coloration and leaf drop may occur; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • avoid excessive fertilization since tender, succulent leaves are more susceptible; • provide good air circulation around the tree; • spraying is usually not necessary since the disease has no significant impact on tree health; on specimen trees, fungicides can be applied as soon as symptoms are evident and repeated as necessary; • if nuts are harvested for consumption, check the fungicide label.	fenarimol thiophanate-methyl

Cotinus (Smoke Tree)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Armillaria Root Rot *(Armillaria* spp. *complex)* p. 326	Also called shoestring root rot and honey mushroom rot; this disease is difficult to identify since aboveground symptoms appear as general and progressive decline that leads to the eventual death of trees; trees can die singly or in groups; trees under environmental or site-related stresses are particularly susceptible; diagnostic signs of the infection include black strands of the fungus called rhizomorphs (shoestrings) on the surface of the bark or at the base of infected trees, white fans of fungal growth with “mushroomy” odors under the bark, and the occasional growth of honey mushrooms at the base of infected trees in autumn; narrow, black lines are often evident in infected wood; the fungus can persist in stumps and large, woody roots for as long as 30 years.	• maintain tree vigor; • avoid any unnecessary stresses, esp. drought stress; • avoid planting susceptible trees in a site where this disease has been confirmed; • if replanting in the site, the stump and all woody roots greater than ½ inch in diameter should be removed.	No chemical control is suggested.
Botryosphaeria Canker *(Botryosphaeria* spp.*)* p. 120	Random dieback of branches and limbs; usually associated with sunken cankers in which black fruiting structures of the fungus may be visible; problematic on trees weakened by other factors such as drought.	• prune affected limbs back to healthy wood as soon as detected and when bark is dry; • avoid wounding and other unnecessary stresses, esp. drought stress; • maintain tree vigor.	No chemical control is suggested.

Cotinus (Smoke Tree) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Powdery Mildew *(Erysiphe)* p. 8	White to grayish, powdery growth on leaves, usually first evident on upper leaf surfaces but can occur on both surfaces of leaves; develops fairly late in the season; some premature fall coloration and leaf drop may occur; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • avoid excessive fertilization since tender, succulent leaves are more susceptible; • provide good air circulation around the tree; • spraying is usually not necessary since the disease has no significant impact on tree health; on specimen trees, fungicides can be applied as soon as symptoms are evident and repeated as necessary; • if nuts are harvested for consumption, check the fungicide label.	fenarimol thiophanate-methyl
Verticillium Wilt *(Verticillium* spp.*)* p. 242	Flagging or wilting of individual limbs or portions of the canopy, usually in midsummer; leaves can be undersized; trees die slowly or suddenly, depending on the extent of infection and overall health of the tree; a distinctive olive to brown discoloration or streaking may be evident in the wood of symptomatic branches or twigs; laboratory examination and culturing are usually required for definitive identification; a common cause for tree death; refer to fact sheet for more detailed information.	• prune and remove affected limbs as soon as symptoms are evident; • disinfest tools between cuts; • promote tree vigor by fertilizing and watering; • do not replant susceptible species in the area since the fungus is soilborne (refer to list of resistant species, Table 1).	No chemical control is suggested.

Cotoneaster (Cotoneaster)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Canker *(Botryosphaeria)* p. 120	Progressive wilting and dieback of branches; infected limbs are covered with black, pinpoint fruiting structures of the fungus; wood in the affected areas is usually discolored; stressed plants are highly susceptible.	• prune and remove symptomatic twigs and branches; • maintain tree vigor; • avoid wounding or unnecessary stresses, esp. drought stress.	No chemical control is suggested.
Fire Blight *(Erwinia amylovora)* p. 376	Flowers wither and blacken; young twigs and branches die from the terminals back and appear as though "burned"; dead leaves usually remain attached to the branch; sunken, discolored cankers may be evident on branches or the main trunk; symptoms often develop in a relatively short period of time; plants are often killed by this disease; refer to fact sheet for more detailed information.	• prune and remove infected branches, making cuts at least 10-12 inches below visible symptoms when bark is dry; • carefully remove prunings to avoid spread; • disinfest tools between cuts; • avoid excessive nitrogen fertilization or vigor; • many species are reported to be resistant (e.g., *C. adpressa*, *C. microphylla*, *C. francheti*).	No chemical control is suggested.

Crataegus (Hawthorn)

Disease *(Pathogen/Cause)*	Diagnostic Symptoms	Management	Materials
Botrytis Blight *(Botrytis cinerea)* p. 72	Irregular, necrotic patches develop on senescing flowers and leaves in wet weather; lesions expand and disease spreads when senescingflowers fall on asymptomatic leaves; infected tissues are frequently covered with a distinctive grayish-brown, fuzzy mass of fungal growth that gives this disease the common name "gray mold."	• rake and remove fallen leaves; • maintain tree vigor; • IF conditions are wet during bloom, preventative fungicides can be applied at budbreak and repeated as necessary during the season according to label directions.	chlorothalonil chlorothalonil + thiophanate-methyl copper sulphate pentahydrate mancozeb mancozeb + copper hydroxide mancozeb + thiophanate-methyl *potassium bicarbonate thiophanate-methyl
Entomosporium Leaf Spot [Hawthorn Leaf Blight] *(Diplocarpon mespili)* p. 78	Numerous small, reddish-brown spots appear on upper surfaces of leaves; as they increase in size, they frequently coalesce and result in significant mid-summer defoliation; English hawthorn (*C. oxycantha*) and 'Paul's Scarlet' (*C. oxycantha* var. *paulii*) are particularly susceptible.	• rake and remove fallen leaves; • maintain tree vigor; • provide good air circulation and avoid overhead irrigation; • for specimen trees, fungicides can be applied at budbreak and repeated 2-3 times as necessary according to label directions.	chlorothalonil chlorothalonil + iprodione chlorothalonil + thiophanate-methyl mancozeb mancozeb + thiophanate-methyl myclobutanil thiophanate-methyl

Crataegus (Hawthorn) cont'd

Disease *(Pathogen/Cause)*	Diagnostic Symptoms	Management	Materials
Fire Blight *(Erwinia amylovora)* p. 376	Flowers wither and blacken; young twigs and branches die from the terminals back and appear as though "burned"; affected limbs frequently develop a characteristic shepherd's crook at the tip; dead leaves usually remain attached to the branch; sunken, discolored cankers may be evident on branches or the main trunk; trees are often killed by this disease; refer to fact sheet for more detailed information.	• avoid excessive nitrogen fertilization or vigor; • overwintering cankers should be pruned and removed during the winter; make cuts at least 10-12 inches below visible symptoms when bark is dry; • during the growing season, prune and remove infected branches as soon as they develop; make cuts at least 10-12 inches below visible symptoms when bark is dry; • carefully remove prunings to avoid spread; • disinfest tools between cuts; • preventative copper sprays can be applied to the bark before growth emerges in spring; additional applications may be necessary to protect newly emerging shoots until flowering.	*copper hydroxide copper sulphate pentahydrate mancozeb + copper hydroxide
Powdery Mildew *(Phyllactinia)* p. 8	White to grayish, powdery growth on leaves, usually first evident on upper leaf surfaces but can occur on both surfaces of leaves; develops fairly late in the season; some premature fall coloration and leaf drop may occur; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • avoid excessive fertilization since tender, succulent leaves are more susceptible; • provide good air circulation around the tree; • spraying is usually not necessary since the disease has no significant impact on tree health; on specimen trees, fungicides can be applied as soon as symptoms are evident and repeated as necessary.	chlorothalonil + thiophanate-methyl fenarimol mancozeb + thiophanate-methyl *potassium bicarbonate propiconazole thiophanate-methyl triadimefon

Crataegus (Hawthorn) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Rusts *(Gymnosporangium* spp.*)* p. 262	At least nine species of rust fungi attack hawthorn and symptoms vary with rust species; with some species, diagnostic orangy-yellow lesions form on leaves and on fruit and severely affected leaves drop prematurely; other symptoms include swelling and distortion of petioles and twigs or as a twisting and curling of leaves followed by death and drop; severe infections may kill fruit and cause conspicuous leaf and shoot blights; these fungi require other hosts (*Juniperus* spp.) in order to complete their life cycles; refer to fact sheet for more detailed information.	• prune and remove infected branches or limbs; • for specimen trees, eliminate the alternate hosts (any red cedar or juniper species) within a one-mile radius, if possible; • resistant species are available (e.g., Cockspur thorn, *C. crusgalli*; yellow fruited thorn, *C. intricata*; and *C. pruinosa*); • for specimen trees, fungicide sprays can be applied when new growth is emerging in spring and repeated 2-3 times at label intervals; this is usually when the gelatinous, orange telial horns are evident on the junipers (usually mid-May).	chlorothalonil chlorothalonil + iprodione chlorothalonil + thiophanate-methyl copper sulphate pentahydrate fenarimol mancozeb mancozeb + thiophanate-methyl myclobutanil propiconazole triadimefon
Scab *(Venturia inaequalis)* p. 86	Velvety, olive-brown lesions with diffuse margins develop on leaves and fruit; severe infections usually result in significant defoliation; fruit are often cracked and disfigured; refer to fact sheet for more detailed information.	• rake and remove fallen leaves and fruit; • maintain tree vigor; • for specimen trees, fungicide sprays can be applied at budbreak and repeated 2-3 times as necessary at label intervals; early-season sprays are most important.	chlorothalonil + thiophanate-methyl fenarimol mancozeb myclobutanil propiconazole thiophanate-methyl

Cryptomeria (Cryptomeria, Japanese Cedar)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Botryosphaeria Canker *(Botryosphaeria)* p. 120	Random dieback of branches and limbs; usually associated with sunken cankers in which black fruiting structures of the fungus may be visible; problematic on trees weakened by other factors such as drought.	• prune affected limbs back to healthy wood as soon as detected and when bark is dry; • avoid wounding and unnecessary stress due to drought; • maintain tree vigor.	No chemical control is suggested.
Leaf Blight *(Phomopsis)* p. 146	Branch tips turn brown and progressively die back; needles on infected branches usually persist on the tree; small, black fruiting structures may be evident at the base of dead tissues; symptoms are especially pronounced in late winter and early spring.	• maintain vigor; • prune and remove infected twigs and branches when bark is dry; • avoid overhead irrigation and crowding; • fungicide sprays can be applied when new growth appears in the spring and continued at label intervals until tissues are fully elongated and mature.	thiophanate-methyl
Leaf Spot *(Pestalotiopsis)* p. 190	Affected needles and shoots are characterized by progressive yellowing and browning that begins at the tips and moves toward the base of the needles; shoots wilt and brown as the fungus causes girdling cankers in succulent tissues; usually more problematic on weak trees.	• maintain vigor; • prune and remove infected twigs and branches when bark is dry; • avoid overhead irrigation and crowding.	No chemical control is suggested.

Cryptomeria (Cryptomeria, Japanese Cedar) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Wintery Injury *(Abiotic)* p. 492	Affected trees show progressive and significant browning especially in late winter or early spring; in some cases only the needles are affected but in others, cambial tissues are killed; browning can be random in the canopy; this species is problematic in colder climates due to their limited tolerance to cold temperatures in zone 6 and colder, and their susceptibility to winter burn and injury.	• prune and remove infected twigs and branches when bark is dry; • avoid windy, open locations and unnecessary stress due to drought; • maintain vigor.	No chemical control is suggested.

X Cupressocyparis leylandii (Leyland Cypress)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Botryosphaeria Canker *(Botryosphaeria)* p. 120	Random dieback of branches and limbs; usually associated with sunken cankers in which black fruiting structures of the fungus may be visible; problematic on trees weakened by other factors such as drought.	• prune affected limbs back to healthy wood as soon as detected and when bark is dry; • avoid wounding and unnecessary stress due to drought; • maintain tree vigor.	No chemical control is suggested.
Seiridium Canker *(Seiridium cardinal, S. cupressi, S. unicorne)* p. 120	Plants of all ages are affected; random, flagged, off-colored branches develop due to girdling cankers that appear as dark brown or purplish patches on bark; these are often accompanied by extensive resin flow; flagging is often most obvious in early spring, but can develop at any time on branches and limbs; plants stressed by drought and freeze damage are particularly vulnerable; refer to fact sheet for more detailed information.	• prune limbs with cankers back to healthy wood as soon as detected and when bark is dry; • avoid wounding and unnecessary stress due to drought; • maintain tree vigor.	No chemical control is suggested.
Winter Injury *(Abiotic)* p. 492	Affected trees show progressive and significant browning especially in late winter or early spring; in some cases only the needles are affected but in others, cambial tissues and branches are killed; can result in tree death; browning can be random in the canopy; this species is problematic in colder climates due to their limited tolerance to cold temperatures in zone 6 and colder, and their susceptibility to winter burn and injury.	• prune and remove infected twigs and branches when bark is dry; • avoid windy, open locations and unnecessary stress due to drought; • maintain vigor.	No chemical control is suggested.

Euonymus (Euonymus)

Disease *(Pathogen/Cause)*	Diagnostic Symptoms	Management	Materials
Anthracnose *(Glomerella)* p. 114	Small, brown lesions develop on leaves and young shoots; leaves turn brown as individual lesions frequently coalesce, resulting in substantial defoliation; salmon-colored spores can often be seen in infected tissues; the fungus moves into twigs and slightly raised, discolored cankers develop; significant dieback can result when cankers girdle twigs and new shoots; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • prune and remove symptomatic tips and twigs well below visible symptoms when bark is dry; • maintain tree vigor; • avoid mechanical injuries and overhead irrigation; • fungicide applications can be made at budbreak and repeated as necessary at label intervals; since fungicide resistance is well documented for this pathogen, it is important to rotate between different fungicide "families."	azoxystrobin chlorothalonil chlorothalonil + iprodione chlorothalonil + thiophanate-methyl copper hydroxide copper sulphate pentahydrate mancozeb mancozeb + copper hydroxide mancozeb + thiophanate-methyl *potassium bicarbonate propiconazole thiophanate-methyl
Crown Gall *(Agrobacterium tumefaciens)* p. 382	Galls ranging in size from ¼ inch to several inches in diameter develop on branches and roots; young galls appear white or cream-colored when cut in half; older galls darken to brown and have no recognizable internal structure (e.g., no vascular tissue).	• prune and remove young stem galls as soon as evident; • disinfest tools between cuts; • severely infected plants should be rogued and removed; • avoid mechanical injuries to neighboring plants using careful cultivation since the bacterium requires wounds to infect; • plant resistant species (refer to list of resistant species, Table 2).	No chemical control is suggested.

Euonymus (Euonymus) cont’d

Disease *(Pathogen/Cause)*	Diagnostic Symptoms	Management	Materials
Fungal Leaf Spots *(Cercospora, Phyllosticta)* p. 42	Irregular or circular, dead patches develop over the leaves, particularly during wet weather; some early defoliation can occur; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • provide good air circulation and avoid overhead watering; • spraying is usually not necessary since the disease has no significant impact on plant health; for specimen trees, fungicides can be applied at budbreak and repeated as necessary according to label directions.	chlorothalonil chlorothalonil + thiophanate-methyl mancozeb mancozeb + copper hydroxide propiconazole thiophanate-methyl
Powdery Mildew *(Erysiphe)* p. 8	White to grayish, powdery growth on leaves, usually first evident on upper leaf surfaces but can occur on both surfaces of leaves; corky lesions may develop on some species; develops fairly late in the season; some premature fall coloration and leaf drop may occur; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • avoid excessive fertilization since tender, succulent leaves are more susceptible; • provide good air circulation around the tree; • spraying is usually not necessary since the disease has no significant impact on tree health; on specimen trees, fungicides can be applied as soon as symptoms are evident and repeated as necessary.	chlorothalonil + thiophanate-methyl copper sulphate pentahydrate fenarimol myclobutanil *potassium bicarbonate propiconazole *sulfur thiophanate-methyl triadimefon

Fagus (Beech)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Beech Bark Disease *(Neonectria ditissima, N. faginata* and beech scale, *Cryptococcus fagisuga)* p. 184	Infected trees have sparse, often chlorotic foliage and significant branch and twig dieback; circular to elliptical, sunken cankers form on the bark, typically on the main trunk; cankers can result in significant disfigurement of the tree and when they girdle the trunk, trees are killed; upon close inspection of cankered areas, reddish fruiting structures of the fungus are sometimes visible; since the disease is also associated with the woolly beech scale, *Cryptococcus*, white specks and/or waxy secretions of the insect are frequently visible along the trunk in late summer and autumn.	• disease management relies on control of the scale insect since the fungus is introduced through the feeding wounds produced by this insect; • refer to the *Pesticide Guide Toward Integrated Pest Management for Connecticut Arborists* for specific information on insecticides; • maintain general tree health and vigor; • heavily disfigured trees can be removed.	No chemical control is suggested.
Bleeding Canker *(Phytophthora* spp.*)* p. 354	Primary symptoms include oozing of reddish-brown sap from fissures or cracks in the bark; these are usually centered over diffuse cankers; infected inner bark, cambium, and sapwood appear reddish-brown; foliage may be undersized and chlorotic as the cankers enlarge and girdle the trunk; some dieback of branches and thinning of the canopy can occur; can result in tree death; of particular concern on European beech in the past few years in Connecticut; culturing is often necessary for definitive diagnosis.	• maintain tree vigor by attention to irrigation, and soil compaction; • avoid tree stress and mechanical injuries to the trunk; • mildly infected trees have occasionally been reported to recover; • rogue and remove heavily infected trees to reduce the potential of spread to nearby trees; • recent trials have demonstrated anecdotal success (limited efficacy data) with directed basal bark sprays and injections of mono- and di-potassium salts of phosphorus acid. If basal bark sprays are used, label directions suggest high concentrations, so it is important to protect other plants in the vicinity from possible phytotoxicity issues.	mono- and di-potassium salts of phosphorus acid phosphorus acid

Fagus (Beech) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Powdery Mildew *(Erysiphe)* p. 8	White to grayish, powdery growth on leaves, usually first evident on upper leaf surfaces but can occur on both surfaces of leaves; develops fairly late in the season; some premature fall coloration and leaf drop may occur; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • avoid excessive fertilization since tender, succulent leaves are more susceptible; • provide good air circulation around the tree; • spraying is usually not necessary since the disease has no significant impact on tree health; on specimen trees, fungicides can be applied as soon as symptoms are evident and repeated as necessary.	chlorothalonil *sulfur thiophanate-methyl
Sooty Mold *(Scorias spongiosa)* p. 16	Irregular, sponge-like masses of mycelium develop on limbs and trunks of trees infested by the beech blight aphid; the fungus grows on the honeydew excreted by this insect pest; fungal masses are soft and tan at first and gradually become blackened and brittle; they can be quite large and can cover substantial portions of trees, giving them a charred or burned appearance; symptoms are most obvious during the winter.	• no control is necessary; • the fungus is not a pathogen although it can represent an aesthetic problem to landscape trees; large masses of this sooty mold can be pulled from the tree without harm if done carefully; injuries associated with beech blight aphid infestations are presently not quantified and are poorly understood.	No chemical control is suggested.

Forsythia (Forsythia)

Disease *(Pathogen/Cause)*	Diagnostic Symptoms	Management	Materials
Bacterial Blight *(Pseudomonas syringae* pv. *syringae)* p. 370	Symptoms can develop on leaves, shoots, and stems; irregular, water-soaked lesions appear on leaves as they emerge and veins of infected leaves are water-soaked and blackened; lesions often coalesce, blacken, and kill leaves very quickly; when petioles become infected, the pathogen moves into tender wood; shoots and tender stems wilt and blacken; sunken, black cankers can be seen on infected stems; symptoms can easily be confused with frost damage although frost or other types of physical injury can provide sites for infection; this disease has been particularly problematic for the past several years, especially during cool, wet, spring weather.	• prune all symptomatic tissues back to healthy wood as soon as they are evident; this should be done when bark is dry; • disinfest tools between cuts; • maintain vigor but avoid excessive nitrogen fertilization; • provide adequate spacing for good air circulation; • avoid overhead irrigation; • bactericide applications can be made when the new growth is emerging in spring and repeated as necessary at label intervals; these products have limited efficacy against internal infections.	*copper hydroxide copper sulphate pentahydrate mancozeb + copper hydroxide
Fungal Leaf Spots *(Phyllosticta, Alternaria)* p. 42, 84	Irregular or circular, dead patches develop over the leaves, particularly during wet weather; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • spraying is usually not necessary since the disease has no significant impact on plant health; on specimen plants, fungicides can be applied as new growth emerges in spring and repeated as necessary at label intervals.	azoxystrobin mancozeb mancozeb + copper hydroxide *potassium bicarbonate thiophanate-methyl
Gall *(Unknown, Phomopsis?)* p. 148	Numerous abnormal growths, swellings, or knobby galls appear on stems, sometimes resulting in twig dieback; symptoms are similar to those associated with crown gall but, to date, no causal agent has been definitively associated with this deformity.	• prune and remove symptomatic branches to eliminate secondary invaders or opportunistic pests; • maintain vigor.	No chemical control is suggested.

Fraxinus (Ash)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Anthracnose *(Gnomoniella, [Discula])* p. 98	Newly emerging leaves develop brown spots at margins and tips, often resulting in distortion or twisting of the leaves; when infection is heavy, leaves brown and fall prematurely; tender, young twigs can also become infected and girdled resulting in tip dieback; symptoms are frequently most severe on lower portions of the tree; from a distance, individuals or clusters of heavily infected trees often have the appearance of being burned; black and white ash are susceptible and green ash is fairly resistant; very heavy in recent years due to cool, wet conditions during leaf emergence; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • prune affected twigs and limbs when bark is dry; • spraying is usually not necessary but fungicide sprays can be applied at budbreak and repeated 2-3 times as necessary according to label directions.	chlorothalonil chlorothalonil + iprodione chlorothalonil + thiophanate-methyl copper sulphate pentahydrate mancozeb mancozeb + copper hydroxide mancozeb + thiophanate-methyl thiophanate-methyl
Decline *(Unknown Complex)* p. 462	Trees have poor vigor and a general unthrifty appearance; can develop on trees of any age but is frequently found on older trees; other symptoms include canopy thinning, undersized chlorotic foliage, branch dieback, and in extreme cases, whole tree death; particularly affected in Connecticut is white ash; this complex remains poorly understood but is thought to be exacerbated by drought; freeze damage, air pollution; ash yellows (see below) is probably one component of the decline syndrome; recovery is not common; quite noteworthy during the past few years.	• prune and remove dead branches to avoid secondary invaders or opportunistic pests; • maintain tree vigor; • avoid unnecessary stresses or injuries.	No chemical control is suggested.

Fraxinus (Ash) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Fungal Leaf Spots *(Cercospora, Cercosporidium, Septoria)* p. 20	Individual spots or large, necrotic sections develop on leaves after cool, wet, spring weather; some early leaf drop may occur; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • spraying is usually not necessary since the disease has no significant impact on tree health; on specimen trees, fungicides can be applied as soon as new growth begins and repeated as necessary.	chlorothalonil chlorothalonil + iprodione chlorothalonil + thiophanate-methyl mancozeb mancozeb + thiophanate-methyl propiconazole thiophanate-methyl
Leaf Rust *(Puccinia sparaganoides)* p. 270	Yellowish-orange spots develop on leaves and petioles; as the fungus develops in these areas, some distortion of tissues occurs; when lesions girdle petioles, leaves brown and die; in cases of severe infections, trees appear burned or scorched and significant premature leaf drop occurs; repeated years of defoliation can significantly weaken trees and make them more vulnerable to winter injury; this disease has been reported to kill young trees; the fungus requires an alternate host for completion of its life cycle so the disease does not spread directly from ash to ash; the alternate host is *Spartina* (marsh or cord grass); leaf rust fungus overwinters on *Spartina* hosts; refer to fact sheet for more detailed information.	• maintain tree vigor; • remove alternate hosts within close proximity of ash hosts, if possible; • not usually serious enough for control measures; on specimen trees, fungicides can be applied at budbreak and repeated 2-3 times as necessary.	chlorothalonil chlorothalonil + thiophanate-methyl mancozeb myclobutanil thiophanate-methyl

Fraxinus (Ash) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Powdery Mildew *(Erysiphe)* p. 8	White to grayish, powdery growth on leaves, usually first evident on upper leaf surfaces but can occur on both surfaces of leaves; develops fairly late in the season; some premature fall coloration and leaf drop may occur; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • avoid excessive fertilization since tender, succulent leaves are more susceptible; • provide good air circulation around the tree; • spraying is usually not necessary since the disease has no significant impact on tree health; on specimen trees, fungicides can be applied as soon as symptoms are evident and repeated as necessary.	chlorothalonil + thiophanate-methyl copper sulphate pentahydrate propiconazole thiophanate-methyl triadimefon
Verticillium Wilt *(Verticillium* spp.*)* p. 242	This disease is often misdiagnosed since no distinctive vascular discoloration is visible in infected trees; symptoms include sudden scorching and leaf drop, often on a single branch or a portion of a tree; affected branches usually die but occasionally re-foliate; chronic infections can be identified by random patches of chlorotic leaves, reduced growth, and branch dieback; trees can die slowly or suddenly; laboratory examination and culturing are usually required for definitive identification; refer to fact sheet for more detailed information.	• prune and remove affected limbs as soon as symptoms are evident; • disinfest tools between cuts; • promote tree vigor by fertilizing and watering; • do not replant susceptible species in the area since the fungus is soilborne (refer to list of resistant species, Table 1).	No chemical control is suggested.

Fraxinus (Ash) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Yellows ('*Candidatus* Phytoplasma fraxini') p. 390	Infected trees exhibit slow growth, deliquescent branching, undersized leaves, and early budbreak, as much as 1-2 weeks earlier than normal; progressive branch and twig dieback results in thinning of the canopy; witches' brooms and epicormic sprouts may occur along the trunk or at the root collar; white ash is highly susceptible and sustains the most damage; highly susceptible trees usually die 1-3 years adter infection; considered a key contributing factor to the "Decline" syndrome.	• prune and remove symptomatic limbs; • maintain vigor; • phloem-feeding insect vectors such as leafhoppers are believed to be involved in disease transmission but have not yet been identified; • trees confirmed positive for the disease should be removed to eliminate spread of the phytoplasma to other trees in the area; • although green ash is susceptible, it is more tolerant than many other ash species; • wood harvested from infected tres does not serve as a source of inoculum so ti can be used as firewood or chipped for mulch; • install barriers for landscape trees to prevent root grafts from developing; • antibiotic injections of oyxtetracycline are registered but not encouraged.	No chemical control is suggested.

Gleditsia (Honeylocust)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Powdery Mildew *(Erysiphe)* p. 8	White to grayish, powdery growth on leaves, usually first evident on upper leaf surfaces but can occur on both surfaces of leaves; develops fairly late in the season; some premature fall coloration and leaf drop may occur; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • avoid excessive fertilization since tender, succulent leaves are more susceptible; • provide good air circulation around the tree; • spraying is usually not necessary since the disease has no significant impact on tree health; on specimen trees, fungicides can be applied as soon as symptoms are evident and repeated as necessary.	copper sulphate pentahydrate *potassium bicarbonate thiophanate-methyl
Thyronectria Canker *(Nectria austroamericana)* p. 178	Trees have progressively thinning canopies with yellowed or wilted leaves due to the presence of elongate, sunken, reddish-brown discolored annual and perennial cankers on branches or trunks; reddish-brown discoloration can develop in sapwood beneath or near the cankers and can extend into the heartwood; cracks and ridges develop in old cankers and blackened fruiting structures of the fungus are sometimes visible; cankers are frequently associated with pruning wounds or southwest injuries; trees die when the main trunk is girdled by cankers; this disease is exacerbated by drought and site-related stresses; considered the most serious disease of honeylocust in Connecticut.	• prune and remove cankered branches; • avoid unnecessary wounding; • maintain overall vigor; • avoid unnecessary stresses, esp. drought stress; • resistant cultivars are available (e.g., 'Skyline' and 'True shade' appear more resistant than 'Shademaster' or 'Rubylace').	No chemical control is suggested.

Hamamelis (Witch Hazel)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Botryosphaeria Canker *(Botryosphaeria)* p. 120	Random dieback of branches and limbs; usually associated with sunken cankers in which black fruiting structures of the fungus may be visible; problematic on trees weakened by other factors such as site or drought.	• prune affected limbs back to healthy wood as soon as detected and when bark is dry; • avoid wounding and unnecessary stress such as drought stress; • maintain tree vigor.	No chemical control is suggested.
Crown Gall *(Agrobacterium tumefaciens)* p. 382	Galls ranging in size from ¼ inch to several inches in diameter develop on branches and roots; young galls appear white or cream-colored when cut in half; older galls darken to brown and have no recognizable internal structure (e.g., no vascular tissue).	• prune and remove young stem galls as soon as evident; • disinfest tools between cuts; • severely infected plants should be rogued and removed; • avoid mechanical injuries to neighboring plants using careful cultivation since the bacterium requires a wound in order to infect; • plant resistant species (refer to list of resistant species, Table 2).	No chemical control is suggested.
Fungal Leaf Spots *(Phyllosticta)* p. 42	Individual spots or large, necrotic sections develop on leaves during rainy weather; some leaf drop may occur; refer to fact sheet for more detailed information. .	• rake and remove fallen leaves; • spraying is usually not necessary since the disease has no significant impact on tree health; on specimen trees, fungicides can be applied at budbreak and repeated as necessary according to label directions.	mancozeb mancozeb + copper hydroxide thiophanate-methyl

Hamamelis (Witch Hazel) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Powdery Mildew *(Podosphaera)* p. 8	White to grayish, powdery growth on leaves, usually first evident on upper leaf surfaces but can occur on both surfaces of leaves; develops fairly late in the season; some premature fall coloration and leaf drop may occur; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • avoid excessive fertilization since tender, succulent leaves are more susceptible; • provide good air circulation around the tree; • spraying is usually not necessary since the disease has no significant impact on tree health; on specimen trees, fungicides can be applied as soon as symptoms are evident and repeated as necessary.	thiophanate-methyl
Witch Hazel Blight *(Phyllosticta hamamelidis)* p. 42	Individual necrotic spots coalesce to form large blotches and leaves develop a blighted appearance; lesions typically have defined, narrow purple margins; when severe, it can disfigure entire plants; more problematic during rainy weather; significant leaf drop may occur.	• rake and remove fallen leaves; • select resistance cultivars, including *Hamamelis mollis* 'Early Bright' and 'Princeton Gold', *H. x intermedia* 'Primavera', *H. vernalis, H. x intermedia* 'Jelena' and 'Luna' and *H. virginiana*; • spraying is usually not necessary since the disease has no significant impact on tree health; on specimen trees, fungicides can be applied at budbreak and repeated as necessary according to label directions.	mancozeb mancozeb + copper hydroxide

Hibiscus (Rose-of-Sharon)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Botryosphaeria Canker *(Botryosphaeria)* p. 120	Random dieback of branches and limbs; usually associated with sunken cankers in which black fruiting structures of the fungus may be visible; problematic on trees weakened by other factors such as site or drought.	• prune affected limbs back to healthy wood as soon as detected and when bark is dry; • avoid wounding and unnecessary stress such as drought stress; • maintain tree vigor.	No chemical control is suggested.
Botrytis Blight *(Botrytis cinerea)* p. 72	Flowers and flower buds appear shriveled and brown; affected portions are often covered with gray, fuzzy, fungal growth; leaf symptoms can develop if senescing flowers or shriveled buds fall onto leaves during wet weather; more prevalent after periods of prolonged humidity, rain, or cloud cover; can result in some twig dieback.	• prune and remove infected twigs and senescing or blighted flowers; • maintain vigor; • spraying is usually not necessary since the disease has no significant impact on tree health; however, on specimen trees, fungicide sprays can be applied at budbreak in wet springs or when symptoms first appear; sprays can be repeated as necessary according to label directions.	chlorothalonil chlorothalonil + thiophanate-methyl mancozeb mancozeb + copper hydroxide *potassium bicarbonate *sulfur thiophanate-methyl
Canker *(Nectria* spp.) p. 176	Random dieback of branches and limbs; usually associated with sunken cankers that are often covered with distinctive coral-colored or red-orange fruiting structures of the fungus; problematic on trees weakened by other factors such as drought.	• prune affected limbs back to healthy wood as soon as detected and when bark is dry; • avoid wounding; • maintain tree vigor.	No chemical control is suggested.

Hibiscus (Rose-of-Sharon) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Powdery Mildew *(Podosphaera))* p. 8	White to grayish, powdery growth on leaves, usually first evident on upper leaf surfaces but can occur on both surfaces of leaves; develops fairly late in the season; some premature fall coloration and leaf drop may occur; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • avoid excessive fertilization since tender, succulent leaves are more susceptible; • provide good air circulation around the tree; • spraying is usually not necessary since the disease has no significant impact on tree health; on specimen trees, fungicides can be applied as soon as symptoms are evident and repeated as necessary.	thiophanate-methyl

Hydrangea (Hydrangea)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Bacterial Blight *(Pseudomonas)* p. 368	Sudden and conspicuous blighting and dieback of young leaves and inflorescences; infected tissues appear blackened and water-soaked; disease is more severe during cool, wet weather or after late season frosts in spring; quite prevalent in the past few years.	• prune and remove infected twigs 8-10 inches below visible symptoms; • disinfest tools between cuts; • maintain vigor but avoid excessive fertilization; • preventative sprays can be applied when new growth emerges and repeated as necessary.	*copper hydroxide
Bacterial Leaf Spot *(Xanthomonas)* p. 370	Symptoms appear as small, water-soaked spots, usually first on lower leaves, but they quickly spread upward in the plant; the lesions darken with age and become angular and are often delineated by the veins; the centers of the spots frequently drop out; most common under warm, wet conditions in late spring and early summer.	• avoid overhead irrigation and prune to maintain adequate air circulation; • preventative sprays can be applied at budbreak and repeated as necessary according to label directions.	*copper hydroxide copper sulphate pentahydrate
Botrytis Blight *(Botrytis cinerea)* p. 72	Flowers and flower buds appear shriveled and brown; affected portions are often covered with gray, fuzzy, fungal growth; serious after periods of prolonged humidity, rain, or cloud cover; can result in some twig dieback.	• prune and remove infected twigs and senescing or blighted flowers; • maintain vigor; • spraying is usually not necessary since the disease has no significant impact on tree health; however, on specimen trees, fungicide sprays can be applied at budbreak in wet springs or when symptoms first appear; sprays can be repeated as necessary according to label directions.	chlorothalonil chlorothalonil + thiophanate-methyl copper sulphate pentahydrate mancozeb mancozeb + copper hydroxide *potassium bicarbonate *sulfur thiophanate-methyl

Hydrangea (Hydrangea) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Fungal Leaf Spots *(Cercospora, Phyllosticta, Septoria)* p. 20	Individual spots with defined margins or large, necrotic sections develop on leaves during rainy weather; some early leaf drop may occur; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • provide good air circulation around the plant and avoid overhead watering; • spraying is usually not necessary since the disease has no significant impact on plant health; on specimen plants, fungicides can be applied when new growth emerges in spring and repeated as necessary according to label directions.	azoxystrobin chlorothalonil chlorothalonil + iprodione chlorothalonil + thiophanate-methyl copper sulphate pentahydrate mancozeb mancozeb + copper hydroxide myclobutanil thiophanate-methyl
Powdery Mildew *(Erysiphe, Oidium)* p. 8	White to grayish, powdery growth on leaves, usually first evident on upper leaf surfaces but can occur on both surfaces of leaves; develops fairly late in the season; some premature fall coloration and leaf drop may occur; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • avoid excessive fertilization since tender, succulent leaves are more susceptible; • provide good air circulation around the tree; • spraying is usually not necessary since the disease has no significant impact on tree health; on specimen trees, fungicides can be applied as soon as symptoms are evident and repeated as necessary.	azoxystrobin chlorothalonil + thiophanate-methyl copper sulphate pentahydrate fenarimol myclobutanil *potassium bicarbonate thiophanate-methyl triadimefon

Hydrangea (Hydrangea) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Winter Dieback *(Abiotic)* p. 498	Symptoms include dieback of shoots and lack of flowering due to the killing of flower buds by winter conditions; flower buds are more vulnerable to winter kill than leaf or shoot buds; some species of hydrangea (e.g., *H. macrophylla*) are not adequately winter-hardy in many regions of Connecticut; as a consequence, tops often die back to ground level; refer to fact sheet for more detailed information.	• promote overall vigor; • pay attention to plant selection and site; • prune any dead branches; • *H. macrophylla* 'Endless Summer' is a new cultivar that blooms on both old and new wood so it minimizes the impact of winter dieback problems.	No chemical control is suggested.

Ilex (Holly)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Armillaria Root Rot *(Armillaria* spp. *complex)* p. 326	Also called shoestring root rot and honey mushroom rot; this disease is difficult to identify since aboveground symptoms appear as general and progressive decline that leads to the eventual death of trees; trees can die singly or in groups; trees under environmental or site-related stresses are particularly susceptible; diagnostic signs of the infection include black strands of the fungus called rhizomorphs (shoestrings) on the surface of the bark or at the base of infected trees, white fans of fungal growth with "mushroomy" odors under the bark, and the occasional growth of honey mushrooms at the base of infected trees in autumn; narrow, black lines are often evident in infected wood; the fungus can persist in stumps and large, woody roots for as long as 30 years.	• maintain tree vigor; • avoid any unnecessary stresses, esp. drought stress; • avoid planting susceptible trees in a site where this disease has been confirmed; • if replanting in the site, the stump and all woody roots greater than ½ inch in diameter should be removed.	No chemical control is suggested.
Botryosphaeria Canker *(Botryosphaeria)* p. 120	Random dieback of branches and limbs; usually associated with sunken cankers in which black fruiting structures of the fungus may be visible; problematic on trees weakened by other factors such as site or drought.	• prune affected limbs back to healthy wood as soon as detected and when bark is dry; • avoid wounding and unnecessary stress such as drought stress; • maintain tree vigor.	No chemical control is suggested.

Ilex (Holly) cont'd

Disease *(Pathogen/Cause)*	Diagnostic Symptoms	Management	Materials
Botrytis Blight *(Botrytis cinerea)* p. 72	Flowers and flower buds appear shriveled and brown; affected portions are often covered with gray, fuzzy, fungal growth; serious after periods of prolonged humidity, rain, or cloud cover; can result in some twig dieback.	• prune and remove infected twigs and senescing or blighted flowers; • maintain vigor; • spraying is usually not necessary since the disease has no significant impact on plant health; on specimen trees, fungicides can be applied at budbreak and repeated as necessary according to label directions.	chlorothalonil chlorothalonil + thiophanate-methyl copper sulphate pentahydrate mancozeb mancozeb + copper hydroxide *potassium bicarbonate *sulfur thiophanate-methyl
Fungal Leaf Spots *(Cercospora, Phyllosticta)* p. 20	Brown to purple spots develop on leaves during wet weather; some yellowing and leaf drop may occur; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • provide good air circulation and avoid overhead watering; • spraying is usually not necessary since the disease has no significant impact on plant health; on specimen trees, fungicides can be applied at budbreak and repeated as necessary according to label directions.	chlorothalonil chlorothalonil + thiophanate-methyl *copper hydroxide mancozeb mancozeb + copper hydroxide propiconazole thiophanate-methyl
Leaf Blotch [Purple Leaf Scorch] *(Abiotic)*	Irregular, purplish blotches develop on leaves of any age; one of the most common abiotic problems of all species of holly; attributed to as yet undetermined factors but is thought to be associated with nutrient deficiencies.	• maintain vigor; • apply fertilizer based on soil and tissue analyses.	No chemical control is suggested.

Ilex (Holly) cont'd

Disease *(Pathogen/Cause)*	Diagnostic Symptoms	Management	Materials
Powdery Mildew *(Erysiphe)* p. 8	White to grayish, powdery growth on leaves, usually first evident on upper leaf surfaces but can occur on both surfaces of leaves; develops fairly late in the season; some premature fall coloration and leaf drop may occur; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • avoid excessive fertilization since tender, succulent leaves are more susceptible; • provide good air circulation around the tree; • spraying is usually not necessary since the disease has no significant impact on tree health; on specimen trees, fungicides can be applied as soon as symptoms are evident and repeated as necessary.	azoxystrobin chlorothalonil chlorothalonil + thiophanate-methyl copper sulphate pentahydrate mancozeb + copper hydroxide myclobutanil *potassium bicarbonate propiconazole *sulfur thiophanate-methyl triadimefon
Spine Spot *(Abiotic)*	Pinhead-sized, grayish-purple spots appear on leaves and are most obvious in spring; upon close examination with a hand lens, a hole can be seen in the center of each spot; holes were initially thought to occur when spines of adjacent holly leaves punctured neighboring leaves since they often appeared after storms involving high winds; recently suggested to be associated with oviposition scars of certain insects.	• no control is necessary but it can be helpful to provide protection if plants are located in wind-swept areas.	No chemical control is suggested.

Ilex (Holly) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Tar Spot *(Rhytisma)* p. 66	Initial symptoms include small, yellow spots on leaves; these turn reddish-brown, and are often associated with a yellow halo in summer; by autumn, typical black, tar-like stroma are visible on infected leaves.	• rake and remove fallen leaves; • avoid excessive fertilization since tender, succulent leaves are more susceptible; • provide good air circulation around the tree; • spraying is usually not necessary since the disease has no significant impact on tree health; on specimen trees, fungicides can be applied as new growth is emerging in spring and repeated as necessary.	azoxystrobin chlorothalonil chlorothalonil + thiophanate-methyl mancozeb + copper hydroxide myclobutanil *potassium bicarbonate propiconazole thiophanate-methyl triadimefon
Winter Injury/Scorch *(Abiotic)* p. 498	Tan-colored spots or irregular, scorched areas develop on portions or over the entire leaf; upon close examination, the epidermal layers appear shriveled and dry and can sometimes be easily peeled apart; refer to fact sheet for more detailed information.	• maintain vigor; • provide protection if located in wind-swept areas or in areas subject to extreme temperature fluctuations during the winter; • ensure sufficient moisture in the root zone by a deep soaking before the ground freezes.	No chemical control is suggested.

Juglans (Black Walnut, Butternut, Walnut)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Anthracnose *(Gnomonia)* p. 104	Small to irregularly shaped, brown to black spots develop on leaflets; spots are frequently so numerous that they coalesce and form large, dead patches; where lesions are located at leaflet margins, distortion and curling of the leaflet may occur; heavily infected leaves turn brown and drop prematurely, sometimes as early as July or August; significant defoliation is not uncommon; dark-brown lesions may also develop on petioles and fruit husks; refer to fact sheet for more detailed information.	• rake and remove fallen leaves and fruit; • maintain vigor since repeated defoliation can weaken trees; • spraying is usually not necessary since the disease has no significant impact on plant health; on specimen trees, fungicides can be applied at budbreak and repeated as necessary according to label directions.	chlorothalonil chlorothalonil + thiophanate-methyl mancozeb mancozeb + copper hydroxide mancozeb + thiophanate-methyl myclobutanil propiconazole thiophanate-methyl
Bacterial Blight *(Xanthomonas)* p. 374	Infection usually begins on catkins, which appear water-soaked and blackened; water-soaked, pale yellow, angular spots that gradually darken also develop on leaves; when located at leaflet margins, they result in deformity; petioles may also develop angular, dark-brown to black lesions; fruit may be infected at anytime; symptoms on fruit appear as reddish-brown or blackened depressions.	• rake and remove fallen leaves and fruit; • prune any dead or cankered limbs at least 8-10 inches below visible symptoms when bark is dry; • disinfest tools between cuts; • sprays can be applied at prebloom, bloom, and early nutlet stages.	*copper hydroxide mancozeb + copper hydroxide

Juglans (Black Walnut, Butternut, Walnut) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Bunch Disease [Witches' Broom] (phytoplasma in the X-disease group(16SrIII)) p. 390	Fast-growing witches'-brooms develop on trunks and limbs; leaflets in brooms tend to be longer and narrower than normal leaflets and can also be curled and chlorotic; fruit may fall prematurely; extent of symptom development varies with host species; vectors have not been identified.	• rogue and remove heavily infected trees; • maintain vigor; • resistance is variable: *J. nigra* is highly tolerant, *J. ailanthfolia* and *J. microcarpa* are highly intolerant.	No chemical control is suggested.
Canker [Butternut Canker] *(Ophiognomonia clavigignenti-juglandacearum* [formerly *Sirococcus clavigignenti-juglandacearum*] p. 116	This highly destructive disease is **specific to butternut**; cankers can develop on stems, branches, and the main trunk; young cankers appear as elongate, sunken areas, often originating at leaf scars, branch stubs, and buds; they usually have a diagnostic inky-black center and white margin; when bark is peeled back, brown to black, elliptical areas of dead cambium are visible; tree decline and death are common.	• rogue and remove heavily infected trees; • prune and remove infected limbs below visible canker symptoms; • maintain vigor.	No chemical control is suggested.
Powdery Mildew *(Erysiphe)* p. 8	White to grayish, powdery growth on leaves, usually first evident on upper leaf surfaces but can occur on both surfaces of leaves; develops fairly late in the season; some premature fall coloration and leaf drop may occur; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • avoid excessive fertilization since tender, succulent leaves are more susceptible; • provide good air circulation around the tree; • spraying is usually not necessary since the disease has no significant impact on tree health; on specimen trees, fungicides can be applied as soon as symptoms are evident and repeated as necessary.	chlorothalonil + thiophanate-methyl mancozeb + myclobutanil myclobutanil *potassium bicarbonate propiconazole thiophanate-methyl triadimefon

Juglans (Black Walnut, Butternut, Walnut) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Thousand Cankers Disease (*Geosmithia morbida*) and the walnut twig beetle (*Pityophthorus juglandis*)	**TO DATE, THIS DISEASE HAS NOT BEEN CONFIRMED IN CONNECTICUT; IT IS LISTED HERE FOR INFORMATION ONLY;** Eastern black walnut is particularly susceptible to this newly recognized disease; first symptoms include yellowing and flagging of leaves on upper branches followed by progressive dieback; whole trees are killed within 3-4 years after initial symptoms; the disease is named for the numerous small, dark dead areas (cankers) that develop under the bark; each canker is associated with tunneling by the walnut twig beetle that carries the fungus; the cumulative effect is girdling cause by the cankers; numerous small exit holes are often visible on cankered limbs.	• if the disease is suspected, submit samples for accurate diagnosis; • the disease is not federally-regulated but some states have quarantines; • do not transport dead/dying walnut wood or firewood off site; • rapid detection and subsequent removal of infected trees is the primary means of managing this disease.	No chemical control is suggested.

Juniperus (Juniper, Red Cedar)

Disease *(Pathogen/Cause)*	Diagnostic Symptoms	Management	Materials
Botryosphaeria Canker *(Botryosphaeria)* p. 120	Random dieback of branches and limbs; usually associated with elongated, flattened, often resinous cankers in which black fruiting structures of the fungus may be visible; problematic on trees weakened by other factors such as site or drought; girdling cankers can lead to tree death.	• prune affected limbs back to healthy wood as soon as detected and when bark is dry; • avoid wounding and unnecessary stress such as drought stress; • maintain tree vigor.	No chemical control is suggested.
Cercospora Needle Blight *(Pseudo-cercospora juniper) [Cercospora sequoiae* var. *juniper]* p. 32	Symptoms first appear in late-summer and fall on inner branch needles in the lower portion of the canopy; needles turn dull brown, bronzed, or red and drop; small fuzzy, hairy fungal fruiting bodies are visible with a hand lens on affected needles; defoliation progresses upward and outward, giving severely affected trees a spindly appearance; the fungus overwinters on infected needles on living trees; although symptoms develop in late summer and fall, infections occurs in summer.	• maintain vigor; • tree spacing to promote air circulation and reduce humidty is helpful; • prune and remove any diseased or browning branches as soon as they appear; • rogue and remove heavily infected trees; • fungicide sprays may be necessary during wet summers; the initial two application are made in early June and again in early July, followed by a third application in mid- to late-July; once the disease is under control, yearly fungicide sprays are usually not necessary.	mancozeb thiophanate-methyl
Pestalotiopsis Needle Blight *(Pestalotiopsis sp.)* p. 190	The fungus attacks foliage that has been injured or weakened by unfavorable weather or site conditions; symptoms can develop at any time of the year and usually start at the tips of branches; infected needles and small shoot tips turn brown; premature loss of needles disfigures the tree and eventually lowers its vigor; tiny, black fruiting structures can often be seen in infected needles.	• maintain vigor and avoid stress by following sound cultural practices; • tree spacing to promote air circulation and reduce humidty is helpful; • prune and remove any diseased or browning branches as soon as they appear; • fungicide sprays can be applied when growth begins in spring and repeated as necessary at label intervals.	mancozeb thiophanate-methyl

Juniperus (Juniper, Red Cedar) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Phytophthora Root Rot *(Phytophthora* spp.*)* p.366	Infected plants are stunted, off-colored and generally exhibit poor vigor; needles appear dull, olive-green; branches and twigs shrivel; symptoms may be confined to individual branches or may develop progressively until the entire plant is involved; a diagnostic cinnamon-brown discoloration may be evident on the inner bark and cambium at the root/crown area; frequently more serious on shrubs planted in sites where excess water is a persistent problem (e.g., clay soils, low areas); laboratory analysis is usually required for confirmation..	• avoid planting in wet sites or in heavy clay soiol with poor drainage; • once infected, plants cannot be cured; • rogue and remove symptomatic plants and improve drainage; • avoid excessive irrigation and maintain vigor; • some selections of juniper (e.g., 'Andorra'. 'Bar Harbor', 'Shore', *Juniper procumbens* 'Nana') are more susceptible than others; • healthy, uninfected plants adjacent to symptomatic plants can be protected with fungicides applied according to label directions.	fosetyl-Al mefenoxam mono- and di-potassium salts of phosphorus acid phosphorous acid
Red Cedar Decline *(Abiotic)*	Since 2004, many native eastern red cedars (*J. virginiana)* have exhibited dramatic and conspicuous browning and dieback; damage occurred on trees in all age and size classes, care regimes, and locations; tree death has been observed in extreme cases; no pathogens or arthropod pests have been identified; a combination of weather events (e.g., winter, excess water, drought) have been suggested as contributing to the problem; work to identify the causal agent(s) is ongoing; refer to fact sheet for more detailed information.	• maintain vigor; • prune and remove infected twigs and branches; • water during periods of drought.	No chemical control is suggested.

Juniperus (Juniper, Red Cedar) cont'd

Disease *(Pathogen/Cause)*	Diagnostic Symptoms	Management	Materials
Rusts *(Gymnosporangium* spp.*)* p. 260	Several rust species attack juniper and the symptoms vary with species; the most common rusts are cedar-apple (*G. juniperi-virginianae*), cedar-hawthorn (*G. globosum*), and quince (*G. clavipes*); symptoms are first evident during the winter; cedar-apple rust infection results in the formation of smooth, round, brown galls, often with depressions on the surface, on twigs and branches; galls range from marble to golf ball size; other rust species cause somewhat inconspicuous swellings on twigs; in spring, both galls and swollen areas develop their diagnostic bright-orange coloration--gelatinous, telial "horns" appear on galls, and gelatinous, orange patches can be seen oozing out of swollen areas on twigs; in some cases, symptoms can appear dramatically overnight, especially after rain; these fungi require other hosts (many members of the Rose Family) in order to complete their life cycles; refer to fact sheet for more detailed information.	• not considered serious on junipers although limited branch dieback may occur on twigs with galls or near swollen areas of twigs where bark may fall off and girdle the twig; • to reduce disease on the primary hosts (e.g., apple, crabapple, mountain ash, serviceberry), galls and swollen twigs can be pruned and removed during the winter or before spore horns develop in spring; • avoid planting junipers in close proximity to the primary hosts; • resistant species are available (e.g., *J. chinensis* 'Femina,' 'Hetzii,' *J. communis* 'Depressa,' *J. virginiana* 'Tripartita'); more extensive lists are available upon request; • fungicide sprays to juniper are generally not practical in the landscape; however, sprays can be applied in mid- to late summer at regular label intervals.	azoxystrobin chlorothalonil + thiophanate-methyl *copper sulfate mancozeb mancozeb + copper hydroxide mancozeb + thiophanate-methyl myclobutanil thiophanate-methyl triadimefon

Juniperus (Juniper, Red Cedar) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Tip Blight-Abiotic *(Abiotic)*	Tips and whole sections of branches progressively turn brown and die; affected needles usually remain attached to the branches; symptoms are frequently distributed uniformly on the shrub and are most obvious in spring; since secondary fungi occasionally infect these dead tissues, microscopic examination is necessary to rule out fungal tip blights (see below).	• prune and remove as much of the affected portions of the shrub as practical since this helps to reduce problems associated with secondary invaders and opportunistic pests; • maintain vigor.	No chemical control is suggested.
Tip Blight-Kabatina *(Kabatina)* p. 146	Symptoms appear in late winter or early spring, usually before symptoms of Phomopsis; tips and whole sections of branches progressively die and turn brown; affected needles usually remain attached to the branches but symptomatic tips eventually drop off; upon close inspection, black fruiting bodies of the fungus are evident in the ash-brown tissues; microscopic examination is necessary for fungal identification; unlike *Phomopsis*, this fungus usually requires a wound (from mechanical damage or, more frequently, from insect activities) in order to infect; refer to fact sheet for more detailed information.	• prune and remove infected twigs and branches; • avoid overhead irrigation and excessive crowding; • severely infected plants should be rogued and removed; • maintain vigor and control insects; • resistant varieties are available (e.g., *J. chinensis* 'Pfitzeriana,' 'Hetzii'; *J. communis* 'Hibernica'); more extensive lists are available upon request; • fungicide sprays can be applied in midsummer according to label directions.	chlorothalonil + thiophanate-methyl mancozeb thiophanate-methyl

Juniperus (Juniper, Red Cedar) cont'd

Disease *(Pathogen/Cause)*	Diagnostic Symptoms	Management	Materials
Tip Blight-Phomopsis *(Phomopsis)* p. 146	Symptoms appear in early spring and develop throughout the growing season; tips and whole sections of branches progressively die and turn brown; affected foliage turns dull red or brown and then ash-gray; needles usually remain attached to the branches; symptoms are frequently uniformly distributed over the shrub; immature or newly expanding needles are most susceptible; upon close inspection, black fruiting bodies of the fungus are evident on browned tissues; microscopic examination is necessary for fungal identification; refer to fact sheet for more detailed information.	• prune and remove infected twigs and branches; • avoid overhead irrigation and excessive crowding; • severely infected plants should be rogued and removed; • maintain vigor by fertilizing and waterin; • resistant varieties are available (e.g., *J. chinensis* 'Femina,' 'Pfitzeriana aurea'; *J. communis* 'Aureo-spica,' 'Prostrata aurea'; *J. horizontalis* 'Depressa'; *J. virginiana* 'Tripartita'); more extensive lists are available upon request; • fungicide sprays can be applied when growth begins in spring and repeated as necessary at label intervals.	azoxystrobin chlorothalonil chlorothalonil + thiophanate-methyl *copper hydroxide copper sulphate pentahydrate mancozeb mancozeb + copper hydroxide mancozeb + thiophanate-methyl *potassium bicarbonate propiconazole thiophanate-methyl

Kalmia (Mountain Laurel)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Armillaria Root Rot *(Armillaria* spp. *complex)* p. 326	Also called shoestring root rot and honey mushroom rot; this disease is difficult to identify since aboveground symptoms appear as general and progressive decline that leads to the eventual death of trees; trees can die singly or in groups; trees under environmental or site-related stresses are particularly susceptible; diagnostic signs of the infection include black strands of the fungus called rhizomorphs (shoestrings) on the surface of the bark or at the base of infected trees, white fans of fungal growth with "mushroomy" odors under the bark, and the occasional growth of honey mushrooms at the base of infected trees in autumn; narrow, black lines are often evident in infected wood; the fungus can persist in stumps and large, woody roots for as long as 30 years.	• maintain tree vigor; • avoid any unnecessary stresses, esp. drought stress; • avoid planting susceptible trees in a site where this disease has been confirmed; • if replanting in the site, the stump and all woody roots greater than ½ inch in diameter should be removed.	No chemical control is suggested.
Botryosphaeria Canker *(Botryosphaeria)* p. 120	Random dieback of branches and limbs; usually associated with sunken cankers in which black fruiting structures of the fungus may be visible; problematic on trees weakened by other factors such as drought.	• prune affected limbs back to healthy wood as soon as detected and when bark is dry; • avoid wounding and unnecessary stress such as drought stress; • maintain tree vigor.	No chemical control is suggested.

Kalmia (Mountain Laurel) cont'd

Disease (*Pathogen/Cause*)	Diagnostic Symptoms	Management	Materials
Chlorosis (*Abiotic*)	Symptoms often develop on the newest growth, which generally appears pale green or yellow; the veins of yellowed leaves frequently remain green; usually associated with an iron deficiency due to soil and site conditions (e.g., soil pH, root damage due to drought or excess moisture); refer to fact sheet for more detailed information.	• maintain vigor; • test the soil to help determine the cause of the problem.	No chemical control is suggested.
Fungal Leaf Spots (*Pseudocercospora, Pestalotiopsis*) p. 34, 190	Irregular, occasionally circular, gray-brown spots with purple borders develop on leaves; sizes may vary from pinpoint to ½ inch in diameter; dark-brown fruiting structures may be scattered within the spots; infected leaves usually persist on the tree although leaves with many spots may turn yellow and drop prematurely; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • provide good air circulation around the plant and avoid late-day watering; • spraying is usually not necessary since the disease has no significant impact on plant health; on specimen plants, fungicides can be applied at budbreak and repeated as necessary according to label directions.	chlorothalonil chlorothalonil + iprodione chlorothalonil + thiophanate-methyl mancozeb myclobutanil thiophanate-methyl triadimefon
Leaf/Twig Blight **(***Phomopsis*) p. 140	Fairly large, irregular spots develop on leaves, often at the margins; these spots are frequently mistaken for winter injury; lesions can appear "zonated" or have purple margins; when leaf margins are infected, leaves become cupped; severely infected leaves often drop prematurely; the fungus may penetrate tender twigs and cause dieback and blighting of affected shoots; wounds can be important to infection.	• rake and remove fallen leaves; • prune and remove symptomatic twigs or branches; • maintain vigor and avoid wounds; • when infection is heavy, fungicide sprays can be applied when shoots are elongating in spring and continued at label intervals until tissues are mature.	mancozeb thiophanate-methyl

Kalmia (Mountain Laurel) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Necrotic Ringspot (Virus) p. 420	Symptoms appear as distinct, necrotic, reddish-brown ringspots; these are usually scattered in a random pattern over the leaf surface; symptoms are most pronounced on 2-year-old leaves as the new growth emerges; leaves occasionally drop prematurely but the disease does not appear to affect the overall health or vigor of the plant; no insect vectors have been identified to transmit this virus.	• maintain vigor.	No chemical control is suggested.
Phytophthora Root Rot (*Phytophthora* spp.) p. 354	Infected plants generally exhibit poor vigor; leaves appear dull, olive-green, and wilted but usually remain attached to branches; branches and twigs shrivel; symptoms may be confined to individual branches or may develop progressively until the entire plant is involved; a diagnostic cinnamon-brown discoloration may be evident on the inner bark and cambium at the root/crown area; frequently more serious on shrubs planted in sites where excess water is a persistent problem (e.g., clay soils, low areas).	• once infected, plants cannot be cured; • rogue and remove symptomatic plants and improve drainage; • avoid excessive irrigation and maintain vigor; • healthy, uninfected plants adjacent to symptomatic plants can be protected with fungicides applied according to label directions.	fosetyl-Al mefenoxam mono- and di- potassium salts of phosphorus acid phosphorous acid

Kalmia (Mountain Laurel) cont'd

Disease *(Pathogen/Cause)*	Diagnostic Symptoms	Management	Materials
Powdery Mildew *(Erysiphe)* p. 8	White to grayish, powdery growth on leaves, usually first evident on upper leaf surfaces but can occur on both surfaces of leaves; develops fairly late in the season; some premature fall coloration and leaf drop may occur; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • avoid excessive fertilization since tender, succulent leaves are more susceptible; • provide good air circulation around the tree; • spraying is usually not necessary since the disease has no significant impact on tree health; on specimen trees, fungicides can be applied as soon as symptoms are evident and repeated as necessary.	chlorothalonil chlorothalonil + thiophanate-methyl myclobutanil triadimefon
Tip Blight *(Phytophthora* spp.*)* p. 354	Leaves and terminal buds begin to discolor; leaves turn brown and droop; a diagnostic V-shaped, water-soaked discoloration may be evident on the leaves, usually beginning at the point of petiole attachment to the leaf lamina; browning of the petiole often continues as the fungus-like organism moves into the twig; girdling cankers may form on twigs and branches and result in dieback.	• prune and remove affected tips well below obvious symptoms; • avoid excessive vigor; • fungicide sprays can be applied when new growth begins and repeated according to label intervals.	chlorothalonil + thiophanate-methyl mancozeb
Winter Injury *(Abiotic)* p. 498	Browning of leaf tips or margins, often most evident in spring; considerable dieback and shriveling of branches and twigs can also occur; symptoms are most evident in late winter or early spring as growth resumes but can also develop later in the season; refer to fact sheet for more detailed information.	• prune and remove symptomatic tissues to minimize secondary invaders and opportunistic pests; • maintain vigor; • provide adequate moisture in the root zone before the ground freezes; • provide protection in wind-swept areas or in areas prone to extreme temperature fluctuations during the winter.	No chemical control is suggested.

Koelreuteria (Goldenrain Tree)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Armillaria Root Rot *(Armillaria* spp. *complex)* p. 326	Also called shoestring root rot and honey mushroom rot; this disease is difficult to identify since aboveground symptoms appear as general and progressive decline that leads to the eventual death of trees; trees can die singly or in groups; trees under environmental or site-related stresses are particularly susceptible; diagnostic signs of the infection include black strands of the fungus called rhizomorphs (shoestrings) on the surface of the bark or at the base of infected trees, white fans of fungal growth with "mushroomy" odors under the bark, and the occasional growth of honey mushrooms at the base of infected trees in autumn; narrow, black lines are often evident in infected wood; the fungus can persist in stumps and large, woody roots for as long as 30 years.	• maintain tree vigor; • avoid any unnecessary stresses, esp. drought stress; • avoid planting susceptible trees in a site where this disease has been confirmed; • if replanting in the site, the stump and all woody roots greater than ½ inch in diameter should be removed.	No chemical control is suggested.
Botryosphaeria Canker *(Botryosphaeria)* p. 120	Random dieback of branches and limbs; usually associated with sunken cankers in which black fruiting structures of the fungus may be visible; problematic on trees weakened by other factors such as drought.	• prune affected limbs back to healthy wood as soon as detected and when bark is dry; • avoid wounding and unnecessary stress such as drought stress; • maintain tree vigor.	No chemical control is suggested.

Koelreuteria (Goldenrain Tree) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Canker *(Nectria cinnabarina)* p. 176	Small, depressed, dead areas develop on twigs, branches, and the main trunk; as these cankers enlarge, they encircle and girdle the affected plant part and result in death of these tissues; numerous small, coral-colored fruiting structures of the fungus usually form in the cankered areas; symptoms are more pronounced on trees weakened by environmental or site-related stresses.	• prune and remove affected limbs as soon as symptoms are evident; cuts should be made when bark is dry; • disinfest tools between cuts; • promote tree vigor.	No chemical control is suggested.
Verticillium Wilt *(Verticillium* spp.*)* p. 242	Flagging or wilting of individual limbs or portions of the canopy, usually in midsummer; leaves can be undersized; trees die slowly or suddenly, depending on the extent of infection and overall health of the tree; a distinctive olive to brown streaking may be evident in the wood of symptomatic branches or twigs; laboratory examination and culturing of the fungus are usually necessary for definitive identification; refer to fact sheet for more detailed information.	• prune and remove affected limbs as soon as symptoms are evident; • disinfest tools between cuts; • promote tree vigor; • do not replant susceptible species in the area since the fungus is soilborne (refer to list of resistant species, Table 1).	No chemical control is suggested.

Laburnum (Golden-Chain Tree)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Botryosphaeria Canker *(Botryosphaeria)* p. 120	Random dieback of branches and limbs; usually associated with sunken cankers in which pinpoint, black fruiting structures of the fungus may be visible; problematic on trees weakened by other factors such as drought.	• prune affected limbs back to healthy wood as soon as detected and when bark is dry; • avoid wounding; • maintain vigor.	No chemical control is suggested.
Twig Blight *(Fusarium lateritium)* p. 186	Cankers associated with twig dieback cause thinning of the canopy; cankers are annual and are often initiated at wounds; they are elliptical and tan, with purplish-brown margins that make them readily distinguished from adjacent, healthy tissues; cankers are often associated with freeze damage; peach-colored fruiting structures are often found erupting from lenticels within the cankers.	• prune affected limbs back to healthy wood as soon as detected and when bark is dry; • avoid wounding; • maintain vigor.	No chemical control is suggested.

Larix (Larch, Tamarack)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Canker *(Botryosphaeria, Leucostoma)* p. 120, 160	Progressive wilting and dieback of branches; cankered tissues are often flat or sunken; wood under the cankered areas is usually discolored; black, pinpoint fruiting structures of the fungus can be visible in infected bark.	• prune and remove symptomatic twigs or branches back to healthy wood when the bark is dry; • maintain tree vigor; • avoid wounding or unnecessary stresses such as drought stress.	No chemical control is suggested.
Mycosphaerella Needlecast (Mycosphaerella *laricina)* p. 20	Symptoms first appear in early summer, as needles turn chlorotic and brown, often with broad brown to red cross-bands; usually first visible on needles on the lower branches but as the growing season progresses, symptoms move rapidly upward to the crown; small, black fruting bodies visible with a hand lens develop in symptomatic portions of the needles; heavily infected trees appear distinctly off-colored from a distance—in some cases infected needles were retained, whereas in others extensive premature defoliation occurred as early as July.	• maintain tree vigor; • provide good air circulation around the tree to reduce humidity and wetting periods; • European larch *(L. decidua*) is much more susceptible than tamarack *(L. laricina)* and Japanese larch (*L. kaempferi*);	No chemical control is suggested.

Leucothoe (Leucothoe)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Fungal Leaf Spots *(Pseudocercospora, Mycosphaerella, Phyllosticta)* p.34	Necrotic spots with brown to purple margins develop on leaves, especially during wet weather; some leaf drop may occur; purple lesions on stems can girdle and kill small shoots.	• rake and remove fallen leaves; • provide good air circulation and avoid overhead watering; • spraying is usually not necessary since the disease has no significant impact on tree health; on specimen trees, fungicides can be applied at budbreak and repeated as necessary according to label directions.	mancozeb myclobutanl thiophanate-methyl triadimefon
Powdery Mildew *(Erysiphe)* p. 8	White to grayish, powdery growth on leaves, usually first evident on upper leaf surfaces but can occur on both surfaces of leaves; develops fairly late in the season; some premature fall coloration and leaf drop may occur; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • avoid excessive fertilization since tender, succulent leaves are more susceptible; • provide good air circulation around the tree; • spraying is usually not necessary since the disease has no significant impact on tree health; on specimen trees, fungicides can be applied as soon as symptoms are evident and repeated as necessary.	chlorothalonil + thiophanate-methyl myclobutanil *potassium bicarbonate thiophanate-methyl triadimefon
Winter Injury *(Abiotic)* p. 498	Browning of leaf tips or margins, often most evident in spring; considerable dieback and shriveling of branches and twigs can occur; symptoms are most evident in late winter or early spring as growth resumes but can also develop later in the season; refer to fact sheet for more detailed information.	• prune and remove symptomatic tissues to minimize secondary invaders and opportunistic pests; • maintain vigor; • provide adequate moisture in the root zone before the ground freezes; • provide protection in wind-swept areas or in areas prone to extreme temperature fluctuations during the winter.	No chemical control is suggested.

Ligustrum (Privet)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Alternaria Leaf Spot (*Alternaria* spp.) p.84	This is an emerging disease of privet first observed in 2009; symptoms appear as necrotic spots or blotches on leaves, which often have a subtle concentric ring pattern; leaves then yellow and drop prematurely; symptoms more severe in the center, denser portions of plants; infected shrubs appear very thin by the end of the season; more problematic during cool, wet spring weather.	• rake and remove fallen leaves; • reduce plant stress by maintaining soil health and proper nutrition, pH, and irrigation; • chemical control is usually not necessary except for new transplants, young or specimen plants, or when defoliation has been heavy for several years; fungicides can be applied at budbreak and repeated 2-3 times according to label directions.	chlorothalonil copper hydroxide copper hydroxide + mancozeb mancozeb thiophanate-methyl
Anthracnose/Twig Blight *(Glomerella)* p. 114	Symptoms include development of irregular, necrotic spots on leaves followed by shriveling and drying of the leaves; a blighting of twigs can also occur; when cankers develop and girdle main shoots, plant death can occur; pinkish pustules of the fungus are sometimes visible during wet weather; plants weakened by environmental stress and poor nutrition are particularly susceptible.	• rake and remove fallen leaves; • prune infected twigs and branches when bark is dry; • maintain vigor; • chemical control is usually not necessary except for new transplants, young or specimen plants, or when defoliation has been heavy for several years; preventative fungicides can be applied at budbreak and repeated 2-3 times according to label directions.	chlorothalonil chlorothalonil + thiophanate-methyl mancozeb mancozeb + thiophanate-methyl *potassium bicarbonate propiconazole thiophanate-methyl

Ligustrum (Privet) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Armillaria Root Rot *(Armillaria* spp. *complex)* p. 326	Also called shoestring root rot and honey mushroom rot; this disease is difficult to identify since aboveground symptoms appear as general and progressive decline that leads to the eventual death of plants; trees can die singly or in groups; plants under environmental or site-related stresses are particularly susceptible; diagnostic signs of the infection include black strands of the fungus called rhizomorphs (shoestrings) on the surface of the bark or at the base of infected plants, white fans of fungal growth with "mushroomy" odors under the bark, and the occasional growth of honey mushrooms at the base of infected plants in autumn; narrow, black lines are often evident in infected wood; the fungus can persist in stumps and large, woody roots for as long as 30 years.	• maintain vigor; • avoid any unnecessary stresses, esp. drought stress; • avoid planting susceptible plants in a site where this disease has been confirmed; • if replanting in the site, the stump and all woody roots greater than ½ inch in diameter should be remove.	No chemical control is suggested.
Oedema *(Abiotic)*	Symptoms appear as raised, water-soaked blisters that eventually become corky and tan to rusty-brown; they develop primarily on lower leaf surfaces but can extend to petioles and tender, new shoots.	• maintain vigor.	No chemical control is suggested.

Ligustrum (Privet) cont'd

Disease *(Pathogen/Cause)*	Diagnostic Symptoms	Management	Materials
Powdery Mildew *(Erysiphe)* p. 8	White to grayish, powdery growth on leaves, usually first evident on upper leaf surfaces but can occur on both surfaces of leaves; develops fairly late in the season; some premature fall coloration and leaf drop may occur; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • avoid excessive fertilization since tender, succulent leaves are more susceptible; • provide good air circulation around the plant; • spraying is usually not necessary since the disease has no significant impact on plant health; on specimen plants, fungicides can be applied as soon as symptoms are evident and repeated as necessary.	chlorothalonil + thiophanate-methyl myclobutanil *potassium bicarbonate propiconazole thiophanate-methyl triadimefon

Liquidambar (Sweetgum)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Bleeding Necrosis *(Botryosphaeria)* p. 120	Profuse bleeding on branches and bark such that these areas appear shiny or oily; upon close examination, numerous discolored cankers are usually visible in these areas; occasional callus growth can occur but cankers frequently coalesce and girdle the branch or trunk; young infections have a distinctive phenolic odor; inner bark and wood in cankered areas are usually discolored and brown; infected trees may die in a relatively short time when cankers girdle the trunk; can be quite destructive.	• prune and remove cankered limbs well below visible symptoms as soon as possible; • maintain tree vigor; • rogue and remove heavily infected trees.	No chemical control is suggested.
Fungal Leaf Spots *(Cercospora, Septoria)* p. 34	Brown, necrotic spots develop on leaves, especially during wet weather; some early leaf drop may occur; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • spraying is usually not necessary since the disease has no significant impact on tree health; on specimen trees, fungicides can be applied at budbreak and repeated as necessary according to label directions.	mancozeb propiconazole thiophanate-methyl

Liriodendron (Tuliptree)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Canker *(Botryosphaeria)* p. 120	Probably the most destructive disease of tuliptrees in the landscape; characterized by progressive wilting and dieback of branches; cankered tissues are often flat or sunken; wood under the cankered areas is usually discolored; black, pinpoint fruiting structures of the fungus can be visible in infected bark.	• prune and remove symptomatic twigs and branches; • maintain tree vigor; • avoid wounding or unnecessary stresses, esp. drought stress.	No chemical control is suggested.
Fungal Leaf Spots *(Gloeosporium, Phyllosticta)* p. 42	Circular, brown spots develop on leaves during wet weather; some leaf drop may occur when infection is heavy; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • spraying is usually not necessary since the disease has no significant impact on tree health; on specimen trees, fungicides can be applied when new growth emerges and repeated as necessary according to label directions.	mancozeb thiophanate-methyl
Leaf Yellowing *(Abiotic)*	Leaves begin to yellow and drop prematurely in midsummer after extended periods of hot, dry weather.	• maintain tree vigor.	No chemical control is suggested.
Powdery Mildew *(Erysiphe)* p. 8	White to grayish, powdery growth on leaves, usually first evident on upper leaf surfaces but can occur on both surfaces of leaves; develops fairly late in the season; some premature fall coloration and leaf drop may occur; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • avoid excessive fertilization since tender, succulent leaves are more susceptible; • provide good air circulation around the tree; • spraying is usually not necessary since the disease has no significant impact on tree health; on specimen trees, fungicides can be applied as soon as symptoms are evident and repeated as necessary.	*potassium bicarbonate propiconazole thiophanate-methyl

Liriodendron (Tuliptree) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Sooty Mold *(Capnodium)* p.16	Leaves, stems, and branches are covered with black, sooty, fungal growth; while not a pathogen of the tree, this fungus represents an aesthetic problem; the sooty mold fungus grows on the honeydew associated with infestations by tuliptree aphids and scales.	• control insect pests, particularly aphids and scales; • sooty mold itself is not a problem but an indication of these insect problems; • maintain tree vigor.	No chemical control is suggested.
Verticillium Wilt *(Verticillium* spp.*)* p. 242	Flagging or wilting of individual limbs or portions of the canopy, usually in midsummer; leaves can be undersized; trees die slowly or suddenly, depending on the extent of infection and overall health of the tree; a distinctive olive or brown streaking may be evident in the wood of symptomatic branches or twigs; laboratory examination and culturing of the fungus are necessary for definitive identification; refer to fact sheet for more detailed information; refer to fact sheet for more detailed information.	• prune and remove affected limbs as soon as symptoms are evident; • disinfest tools between cuts; • promote tree vigor; • do not replant susceptible species in the area since the fungus is soilborne (refer to list of resistant species, Table 1).	No chemical control is suggested.

Lonicera (Honeysuckle)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Leaf Blight *(Insolibasidium deformans)* p. 254	Blight symptoms develop in early spring; newly emerging leaves turn yellow and brown and appear twisted and rolled; diffuse tan spots with yellow margins can also develop on leaves later in the season; as these lesions coalesce, large sections of leaves appear tan and necrotic; severely diseased leaves drop prematurely; white, powdery masses of fungal spores are sometimes visible on undersurfaces of leaves during wet weather; this disease is particularly severe in wet weather; usually only a problem in nurseries.	• rake and remove fallen leaves; • provide good air circulation and avoid overhead watering; • maintain vigor; • spraying is usually not necessary if the infection is light; however, on specimen plants, fungicides can be applied as soon as new growth emerges and repeated as necessary according to label directions.	mancozeb mancozeb + copper hydroxide
Powdery Mildew *(Erysiphe)* p. 8	White to grayish, powdery growth on leaves, usually first evident on upper leaf surfaces but can occur on both surfaces of leaves; develops fairly late in the season; some premature fall coloration and leaf drop may occur; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • avoid excessive fertilization since tender, succulent leaves are more susceptible; • provide good air circulation around the plant; • spraying is usually not necessary since the disease has no significant impact on plant health; on specimen plants, fungicides can be applied as soon as symptoms are evident and repeated as necessary.	myclobutanl thiophanate-methyl

Magnolia (Magnolia)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Leaf Spots *(Alternaria, Mycosphaerella)* p. 20	Lesions can appear as minute, purplish-black spots that enlarge to ¾ inch or more or they can remain as small, discrete, brown spots; some early leaf drop may occur; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • provide good air circulation around the tree; • maintain tree vigor; • spraying is usually not necessary since the disease has no significant impact on tree health; on specimen trees, fungicides can be applied when new growth emerges and repeated as necessary according to label directions.	azoxystrobin chlorothalonil chlorothalonil + thiophanate-methyl *copper hydroxide mancozeb mancozeb + copper hydroxide propiconazole thiophanate-methyl
Powdery Mildew *(Erysiphe)* p. 8	White to grayish, powdery growth on leaves, usually first evident on upper leaf surfaces but can occur on both surfaces of leaves; develops fairly late in the season; some premature fall coloration and leaf drop may occur; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • avoid excessive fertilization since tender, succulent leaves are more susceptible; • provide good air circulation around the tree; • spraying is usually not necessary since the disease has no significant impact on tree health; on specimen trees, fungicides can be applied as soon as symptoms are evident and repeated as necessary.	chlorothalonil + thiophanate-methyl copper sulphate pentahydrate myclobutanil propiconazole thiophanate-methyl

Magnolia (Magnolia) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Verticillium Wilt *(Verticillium* spp.*)* p. 242	Flagging or wilting of individual limbs or portions of the canopy, usually in midsummer; leaves can be undersized; trees die slowly or suddenly, depending on the extent of infection and overall health of the tree; a distinctive olive to brown streaking may be evident in the wood of symptomatic branches or twigs; laboratory examination and culturing of the fungus are necessary for definitive identification; refer to fact sheet for more detailed information; refer to fact sheet for more detailed information.	• prune and remove affected limbs as soon as symptoms are evident; • disinfest tools between cuts; • promote tree vigor; • do not replant susceptible species in the area since the fungus is soilborne (refer to list of resistant species,Table 1).	No chemical control is suggested.

Malus (Apple, Crabapple)

Disease *(Pathogen/Cause)*	Diagnostic Symptoms	Management	Materials
Botryosphaeria Canker *(Botryosphaeria* spp.) p. 120	Random dieback of branches and limbs; usually associated with sunken cankers in which pinpoint, black fruiting structures of the fungus may be visible; problematic on trees weakened by other factors such as drought.	• prune affected limbs back to healthy wood as soon as detected and when bark is dry; • avoid wounding and unnecessary stress, esp. drought stress; • maintain tree vigor	No chemical control is suggested.
Fire Blight *(Erwinia amylovora)* p. 376	While only an occasional problem, when infection does occur, disease can develop quite rapidly and destroy individual trees in a single season; flowers appear water-soaked, burned, and then shrivel but usually remain attached to the tree throughout the season; when new shoots are infected they develop a distinctive "shepherd's crook" and appear scorched or burned; blackened leaves cling to the branch and don't fall off; cankers, identified as sunken, discolored areas on branches or the main trunk, may appear wet and oozing during wet weather in spring; remove wild or worthless hosts (e.g., abandoned apple, pear, quince) in the immediate vicinity to reduce sources of the bacterium; refer to fact sheet for more detailed information.	• avoid excessive nitrogen fertilization or vigor; • overwintering cankers should be pruned and removed during the winter; make cuts at least 10-12 inches below visible symptoms when bark is dry; • during the growing season, prune and remove infected branches as soon as they develop; make cuts at least 10-12 inches below visible symptoms when bark is dry; • carefully remove prunings to avoid spread; • disinfest tools between cuts; • recent studies with infected fruit trees have shown that this old method of cutting 8-10 inches below visible symptoms of growing-season blight strikes has certain limitations; new research has shown that bacteria can sometimes be found as far as 9 feet beyond visible symptoms on highly susceptible trees; they suggest that cuts on symptomatic shoots should be made back to 2-year or older wood and at least 8-12 inches below the visible symptoms; • continued on next page;	*copper hydroxide copper sulphate pentahydrate mancozeb + copper hydroxide

Malus (Apple, Crabapple) cont'd

Disease *(Pathogen/Cause)*	Diagnostic Symptoms	Management	Materials
Fire Blight (Cont'd)		• these cuts often leave a 4-5 inch naked stub above the next leaf or branch, so this method has been called the "ugly stub" method; cuts should be made when the bark is dry; the presence of "ugly stubs" in the tree will flag infection sites for follow-up with winter pruning; • cultivars vary in susceptibility and resistant varieties are available (e.g., *Malus baccata* 'David,' 'Dolgo'; *M. hupehensis* 'Indian Summer,' 'Red Baron'; *M. sargentii* 'Sentinel'); a more extensive list is available upon request; • preventative copper sprays can be applied to the bark before growth emerges in spring; additional applications may be necessary to protect newly emerging shoots until flowering; select the appropriate product if harvesting fruit for consumption; • although streptomycin is registered, it is discouraged for ornamental use to reduce the potential for resistance development in the bacterial populations (resistance to streptomycin is widespread in many large fruit producing regions of the U.S.)	

Malus (Apple, Crabapple) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Frogeye Leaf Spot [Black Rot] *(Botryosphaeria obtusa)* p. 126	Symptoms can develop on leaves, fruit, and stems; leaf symptoms first appear as small, purple flecks; they enlarge to ¼ inch and have purple margins and tan centers (giving a frogeye appearance); heavily infected leaves become chlorotic and drop; fruit are infected when young but symptoms don't appear until they begin to mature; lesions appear black, sunken, and develop concentric rings; stem cankers appear as discolored, sunken, or flattened areas; bark is often rough in and around the cankered areas.	• rake and remove fallen leaves; • prune and remove overwintering cankers when bark is dry; • fungicide sprays are usually not necessary for established, landscape trees that are not intended to produce fruit for consumption; on specimen trees, newly transplanted trees, or trees intended to produce crops for consumption, spraying can begin when new growth emerges and repeated as necessary at label intervals; • select the appropriate fungicide if harvesting fruit for consumption.	chlorothalonil chlorothalonil + iprodione chlorothalonil + thiophanate-methyl mancozeb *sulfur
Nectria Canker *(Nectria* spp.) p. 176	Random dieback of branches and limbs; usually associated with sunken cankers that are often covered with distinctive coral-colored or orange fruiting structures of the fungus; problematic on trees weakened by other factors such as winter or drought	• prune affected limbs back to healthy wood as soon as detected and when bark is dry; • avoid wounding; • maintain tree vigor.	No chemical control is suggested.

Malus (Apple, Crabapple) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Powdery Mildew *(Podosphaera)* p. 8	White to grayish, powdery growth on leaves, usually first evident on the upper leaf surfaces; typically develops fairly late in the season; however, when infection occurs early in the season when tissues are young, some distortion and twisting of leaves and tips can occur; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • provide good air circulation around the tree; • resistance has been reported (e.g., *Malus* 'Adams'; *M. baccata*, 'Bob White,' 'Donald Wyman'); • spraying is usually not necessary since the disease has no significant impact on tree health; on specimen trees, fungicides can be applied as soon as symptoms are evident and repeated as necessary according to label directions; • select the appropriate fungicide if harvesting fruit for consumption.	chlorothalonil chlorothalonil + iprodione chlorothalonil + thiophanate-methyl copper sulphate pentahydrate mancozeb + copper hydroxide mancozeb + thiophanate-methyl myclobutanil *potassium bicarbonate propiconazole thiophanate-methyl triadimefon trifloxystrobin

Malus (Apple, Crabapple) cont'd

Disease *(Pathogen/Cause)*	Diagnostic Symptoms	Management	Materials
Rusts *(Gymnosporangium* spp.*)* p. 262	Since several rust species attack this host, symptoms can vary; the most common rusts in the landscape are cedar-apple (*G. juniperi-virginianae*), cedar-hawthorn (*G. globosum*), and quince (*G. clavipes*); distinctive yellowish-orange spots first appear on upper leaf surfaces in late May or June; as the fungus develops in the leaf, spots become noticeable on the undersurfaces; on close examination and depending on which species of fungus is responsible, rings of small, cup-like structures or long, tendrils of the fungus are visible; heavily infected leaves become chlorotic and often drop prematurely by mid-July; these rust fungi require other hosts (*Juniperus* spp.) in order to complete their life cycles; refer to fact sheet for more detailed information.	• for specimen trees, eliminate the alternate hosts (any red cedar or juniper species) within a one-mile radius, if possible; • resistant species are available (e.g., *M. baccata* 'Ellwangerina'; *M. floribunda* 'Henry Kohankie,' 'Ormiston Roy,' 'Red Baron'); a more extensive list is available upon request; • fungicide sprays can be applied when new growth is emerging in spring; this is usually when the gelatinous, orange telial horns are visible on the junipers (usually mid-May); sprays are repeated as necessary at label intervals; • select the appropriate fungicide if harvesting fruit for consumption.	chlorothalonil chlorothalonil + iprodione chlorothalonil + thiophanate-methyl fenarimol mancozeb mancozeb + thiophanate-methyl myclobutanil propiconazole *sulfur thiophanate-methyl triadimefon trifloxystrobin

Malus (Apple, Crabapple) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Scab *(Venturia inaequalis)* p. 86	Symptoms appear as distinctive circular, olive-black, velvety spots with feathery, diffuse margins; they can develop on leaves, fruit, and young fruit stems; leaf lesions often first appear along the midvein but can develop anywhere on the leaf; heavily infected leaves yellow prematurely and highly symptomatic trees defoliate by midsummer; lesions on infected fruit can crack as the fruit expand; when infection is heavy, fruit can drop prematurely; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • prune dead twigs and branches; • maintain vigor since repeated defoliation weakens trees; • resistant cultivars are available (e.g., *M. baccata* 'Cotton Candy,' 'Dolgo,' 'Donald Wyman'; *M. sargentii* 'Tina,' 'Sentinel'); • for ornamental trees, chemical control is usually not necessary except for new transplants, young or specimen trees, or when defoliation has been heavy for several years; fungicide sprays can be applied at budbreak and repeated 2-4 times at label intervals; early-season sprays are very important; • for trees grown for fruit production, susceptible varieties usually require a season-long fungicide program in order to harvest quality fruit; select the appropriate fungicide if harvesting fruit for consumption.	chlorothalonil chlorothalonil + iprodione chlorothalonil + thiophanate-methyl copper sulphate pentahydrate fenarimol mancozeb mancozeb + thiophanate-methyl myclobutanil propiconazole thiophanate-methyl trifloxystrobin

Metasequoia (Dawn Redwood)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Canker *(Botryosphaeria)* p. 120	Random dieback of branches and limbs; usually associated with sunken cankers in which black fruiting structures of the fungus may be visible; problematic on trees weakened by stress factors such as drought.	• prune affected limbs back to healthy wood as soon as detected and when bark is dry; • avoid wounding and other unnecessary stresses, esp. drought stress; • maintain tree vigor.	No chemical control is suggested.

Morus (Mulberry)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Canker *(Botryosphaeria)* p. 120	Symptoms include progressive dieback of twigs and branches, usually first evident on lower limbs and proceeding up the tree; cankers appear as sunken areas of bark on branches or the main trunk.	• prune and remove symptomatic twigs and branches as soon as evident; • cuts should be made below visible symptoms when bark is dry; • maintain vigor since drought-stressed or winter-injured trees are more vulnerable; • avoid mechanical injuries; • maintain vigor.	No chemical control is suggested.
Fungal Leaf Spots *(Cercospora, Cercosporella, Mycosphaerella)* p. 20	Spots can appear as small, brown to black spots; they can be circular or irregular in shape; spots may coalesce to form large blotches; some early leaf drop may occur; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • provide good air circulation around the tree; • maintain tree vigor; • spraying is usually not necessary since the disease has no significant impact on tree health; on specimen trees, fungicides can be applied when new growth emerges and repeated as necessary according to label directions.	copper hydroxide mancozeb + copper hydroxide thiophanate-methyl
Powdery Mildew *(Erysiphe)* p. 8	White to grayish, powdery growth on leaves, usually first evident on upper leaf surfaces but can occur on both surfaces of leaves; develops fairly late in the season; some premature leaf drop may occur; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • avoid excessive fertilization since tender, succulent leaves are more susceptible; • provide good air circulation around the tree; • spraying is usually not necessary since the disease has no significant impact on tree health; on specimen trees, fungicides can be applied as soon as symptoms are evident and repeated as necessary.	mancozeb + copper hydroxide *potassium bicarbonate thiophanate-methyl

Nyssa (Black Gum, Tupelo)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Canker *(Botryosphaeria, Nectria)* p. 120, 176	Symptoms include progressive dieback of twigs and branches, usually first evident on lower limbs and proceeding up the tree; cankers appear as sunken areas of bark on branches or the main trunk.	• prune and remove symptomatic twigs and branches as soon as evident; • cuts should be made below visible symptoms when bark is dry; • maintain vigor since drought-stressed or winter-injured trees are more vulnerable; • avoid mechanical injuries; • maintain vigor.	No chemical control is suggested.

Ostrya (Hop-hornbeam, Ironwood)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Armillaria Root Rot *(Armillaria* spp. *complex)* p. 326	Also called shoestring root rot and honey mushroom rot; this disease is difficult to identify since aboveground symptoms appear as general and progressive decline that leads to the eventual death of trees; trees can die singly or in groups; trees under environmental or site-related stresses are particularly susceptible; diagnostic signs of the infection include black strands of the fungus called rhizomorphs (shoestrings) on the surface of the bark or at the base of infected trees, white fans of fungal growth with "mushroomy" odors under the bark, and the occasional growth of honey mushrooms at the base of infected trees in autumn; narrow, black lines are often evident in infected wood; the fungus can persist in stumps and large, woody roots for as long as 30 years.	• maintain tree vigor; • avoid any unnecessary stresses, esp. drought stress; • avoid planting susceptible trees in a site where this disease has been confirmed; • if replanting in the site, the stump and all woody roots greater than ½ inch in diameter should be removed.	No chemical control is suggested.
Canker *(Nectria,Neonectria)* p. 176, 182	Random dieback of branches and limbs; usually associated with sunken cankers that are often covered with distinctive coral-colored or reddish-orange fruiting structures of the fungus; problematic on trees weakened by other factors such as drought.	• prune affected limbs back to healthy wood as soon as detected and when bark is dry; • avoid wounding; • maintain tree vigor.	No chemical control is suggested.

Ostrya (Hop-hornbeam, Ironwood) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Powdery Mildew *(Erysiphe)* p. 8	White to grayish, powdery growth on leaves, usually first evident on upper leaf surfaces but can occur on both surfaces of leaves; develops fairly late in the season; some premature fall coloration and leaf drop may occur; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • avoid excessive fertilization since tender, succulent leaves are more susceptible; • provide good air circulation around the tree; • spraying is usually not necessary since the disease has no significant impact on tree health; on specimen trees, fungicides can be applied as soon as symptoms are evident and repeated as necessary.	*potassium bicarbonate thiophanate-methyl

Oxydendrum (Sorrel-tree, Sourwood)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Botryosphaeria Canker *(Botryosphaeria)* p. 120	Symptoms include progressive dieback of twigs and branches, usually first evident on lower limbs and proceeding up the tree; cankers appear as sunken areas of bark on branches or the main trunk.	• prune and remove symptomatic twigs and branches as soon as evident; • cuts should be made below visible symptoms when bark is dry; • maintain vigor since drought-stressed or winter-injured trees are more vulnerable; • avoid mechanical injuries; • maintain vigor.	No chemical control is suggested.
Nectria Canker *(Neonectria galligena)* p. 182	Random dieback of branches and limbs; usually associated with sunken or target cankers that are often covered with distinctive reddish-orange fruiting structures of the fungus; cankers are often centered on branch stubs or poor pruning cuts; problematic on trees weakened by other factors such as drought.	• prune affected limbs back to healthy wood as soon as detected and when bark is dry; • avoid wounding and other stresses such as drought stress; • maintain tree vigor.	No chemical control is suggested.

Paulownia (Empress Tree)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Botryosphaeria Canker *(Botryosphaeria)* p. 120	Symptoms include progressive dieback of twigs and branches, usually first evident on lower limbs and proceeding up the tree; cankers appear as sunken areas of bark on branches or the main trunk.	• prune and remove symptomatic twigs and branches as soon as evident; • cuts should be made below visible symptoms when bark is dry; • maintain vigor since drought-stressed or winter-injured trees are more vulnerable; • avoid mechanical injuries; • maintain vigor.	No chemical control is suggested.

Picea (Spruce)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Armillaria Root Rot (*Armillaria* spp. *complex*) p. 326	Also called shoestring root rot and honey mushroom rot; this disease is difficult to identify since aboveground symptoms appear as general and progressive decline that leads to the eventual death of trees; trees can die singly or in groups; trees under environmental or site-related stresses are particularly susceptible; on conifers, excessive resin production at points of infections or at the bases of trees can be important symptoms of infection; the diagnostic black strands of the fungus called rhizomorphs (shoestrings) are usually not present on conifers; signs of the infection includes white fans of fungal growth with "mushroomy" odors under the bark and the occasional growth of honey mushrooms at the base of infected trees in autumn; the fungus can persist in stumps and large, woody roots for as long as 30 years.	• maintain tree vigor; • avoid any unnecessary stresses, esp. drought stress; • avoid planting susceptible trees in a site where this disease has been confirmed; • if replanting in the site, the stump and all woody roots greater than ½ inch in diameter should be removed.	No chemical control is suggested.

Picea (Spruce) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Botrytis Blight *(Botrytis cinerea)* p. 72	Affected tissues initially appear water-soaked and then turn brown; infections are identified by the gray, fuzzy, cottony growth of the fungus on the surface of needles and shoots; the fungus moves from the needles to the shoots and into the stems; with the exception of weak trees, infections usually do not extend beyond the tips or current season's growth and are often confined to tissues that have been damaged by frost; most symptomatic tissues drop off during the season.	• prune and remove symptomatic twigs; • maintain vigor; • attention to planting site to avoid potential frost pockets.	No chemical control is suggested.
Cytospora Canker *(Leucostoma)* p. 168	Symptoms include progressive dieback of twigs and branches, usually first evident on lower limbs and proceeding up the tree; cankers appear as sunken areas of bark on branches or the main trunk but are often very difficult to see because of the nature of the spruce bark; however, heavy amounts of white resin are usually associated with the cankers and can help to identify cankered areas; resin can be so excessive that it drips onto foliage and lower branches; needle drop may occur on infected, girdled branches; Colorado and Norway spruce are particularly susceptible.	• prune and remove symptomatic twigs and branches as soon as evident; • cuts should be made at least 8-10 inches below visible symptoms when bark is dry; • maintain vigor since drought-stressed or winter-injured trees are more vulnerable; • take care in selecting planting site; • avoid mechanical injuries.	No chemical control is suggested.

Picea (Spruce) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Decline *(Abiotic and biotic complex)*	Severe decline has been occurring on spruce in landscape and natural setting throughout the northeast and upper Midwest for the past 4-5 years; contributing factors include needlecasts (*Rhizosphaera, Stigmina*?), cankers (*Cytospora, Phomopsis*), and site or environmental issues; symptoms include loss of interior needles, increased twig and branch dieback, decreased growth, and, in some cases, death of the tree.	• prune and remove symptomatic twigs and branches as soon as evident during dry weather; • maintain vigor since drought-stressed or winter-injured trees appear more vulnerable; • take care in selecting planting site; • avoid mechanical injuries.	No chemical control is suggested.
Phomopsis Canker (*Phomopsis* spp.) p. 144	One of the possible agents thought to be contributing to spruce decline; symptoms usually start at the bottom of the tree, where branches thin and needles drop; shoot tips develop typical shoot blight symptoms and the tissues begin to curl downward and die; numerous cankers develop, coalesce, and result in branch and limb dealth and subsequent needle drop; symptoms move upward on the tree, often giving affected trees a see-through appearance; in some cases, healthy trees can show dramatic decline within two years; stress from environmental and site factors is thought to contribute to this syndrome.	• prune and remove symptomatic twigs and branches as soon as evident during dry weather; • maintain vigor since drought-stressed or winter-injured trees are more vulnerable; • take care in selecting planting site; • avoid mechanical injuries • fungicide sprays can be applied a budbreak and repeated as necessary at label intervals until new shoots are fully developed and hardened off (about 8-10 weeks after budbreak).	chlorothalonil mancozeb thiophanate-methyl

Picea (Spruce) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Phytophthora Root Rot *(Phytophthora* spp.) p. 354	Infected trees generally exhibit poor vigor; needles appear dull olive-green and eventually turn reddish-brown but usually remain attached to branches; branches and twigs die back; symptoms may be confined to individual branches or may develop progressively until the entire tree is involved; excessive resin is sometimes visible on the outer bark at the base of the tree; a diagnostic cinnamon-brown discoloration may be evident on the inner bark and cambium at the root/crown area; frequently more serious on trees growing in sites where excess water is a persistent problem (e.g., clay soils, low areas).	• once infected, trees cannot be cured; • rogue and remove symptomatic trees and improve drainage; • avoid excessive irrigation and maintain vigor; • healthy, uninfected trees adjacent to symptomatic trees can be protected with fungicides applied according to label directions.	fosetyl-Al mefenoxam mono- and di- potassium salts of phosphorus acid phosphorous acid

Picea (Spruce) cont'd

Disease *(Pathogen/Cause)*	Diagnostic Symptoms	Management	Materials
Rhizosphaera Needlecast *(Rhizosphaera)* p. 56	Needles on lower branches are usually attacked first and the symptoms gradually progress up the tree; diagnostic symptoms may develop in September but typically don't appear until spring; infected needles turn a distinctive lavender or purplish-brown; upon close inspection with a hand lens, rows of smooth, round, black spots appear in place of the rows of white stomates on the needles; significant needle drop usually occurs and defoliated twigs and branches eventually die; drought-stressed trees are most susceptible; blue spruce is most susceptible, white spruce is intermediate, and Norway spruce is relatively resistant; often confused with Stigmina needlecast; refer to fact sheet for more detailed information.	• prune and remove infected twigs and branches; • maintain vigor since drought-stressed trees are highly susceptible; • control weeds at base to optimize air circulation; • fungicide sprays can be applied when new growth is approx. 1½ inches long and repeated as necessary at label intervals.	chlorothalonil chlorothalonil + iprodione chlorothalonil + thiophanate-methyl copper hydroxide mancozeb

Picea (Spruce) cont'd

Disease *(Pathogen/Cause)*	Diagnostic Symptoms	Management	Materials
Rusts *(Chrysomyxa weirii* and *Chrysomyxa* spp.*)* p. 288	Although at least ten different rust fungi have been reported on spruce, the most common rust in the landscape in Connecticut is caused by *Chrysomyxa weirii*; the disease caused by this fungus is also called repeating spruce rust or Weir's spruce cushion rust; this rust is autoecious and does not require other hosts to complete its life cycle; most of the other *Chrysomyx*a rusts are heteroecious and require alternate hosts to complete their life cycles; symptoms of rust infections first appear as yellow spots or flecks on needles; these break open to reveal yellow or orange, powdery spores; symptoms of repeating needle rust develop in late winter or early spring whereas symptoms of the heteroecious rusts develop in mid- to late summer; this timing is helpful in determining the type of rust; infected trees are rarely killed but the primary damage is extensive needle discoloration and drop; blue spruce is highly susceptible to repeating spruce rust; black, Englemann red, and Sitka are also susceptible to this rust; Norway and Black Hills spruce are fairly resistant to the heteroecious rusts; refer to fact sheet for more detailed information.	• maintain vigor; • select species • fungicide sprays are only effective for the autoecious rust (repeating needle rust); spraying begins when the new growth emerges in spring and is repeated as necessary at label intervals.	chlorothalonil mancozeb

Picea (Spruce) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Sirococcus Blight *(Sirococcus)* p. 118	Symptoms first appear on succulent shoots and 1-year-old twigs; the fungus attacks at needle bases, girdles the shoot, and results in tip dieback; affected tips turn brown, drop needles, and often develop a characteristic crook or droop; pinpoint, brown fruiting structures may be visible along the stems of dead shoots; affected shoot can develop at random in the tree; refer to fact sheet for more detailed information.	• prune and remove infected shoots when bark is dry; • rogue and remove heavily infected trees; • maintain vigor; • fungicide sprays can be applied when new growth is ½ inch long and repeated as necessary at label intervals.	azoxystrobin chlorothalonil + thiophanate-methyl
Stigmina Needlecast/Needle Blight (*Stigmina lautii*)	Some controversy remains as to whether this fungus is really a pathogen or not—research is ongoing; inside needles on lower branches are usually attacked first and the symptoms gradually progress up the tree; diagnostic symptoms may develop in September but typically don't appear until spring; infected needles turn a distinctive lavender or purplish-brown; when inspected with a hand lens, sparce rows of black spots appear in place of the rows of white stomates on the needles; these are often confused with Rhizosphaera needlecast, but the fruiting bodies of Stigmina are not smooth and have have hairy, feathery projections emerging from them; significant needle drop usually occurs and defoliated twigs and branches eventually die; drought-stressed trees are most susceptible; blue, Norway, white, and Black Hills spruce are susceptible.	• prune and remove infected twigs and branches; • maintain vigor since drought-stressed trees are highly susceptible; • control weeds at base to optimize air circulation; • no fungicides are currently registered for control of this disease; depending on state pesticide laws, fungicide sprays applied when new growth is approx. 1½ inches long and repeated as necessary at label intervals can be effective.	chlorothalonil chlorothalonil + thiophanate-methyl copper hydroxide mancozeb

Pieris (Japanese Andromeda, Pieris)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Canker and Dieback *(Botryosphaeria)* p. 120	Twigs and branch tips wilt and die back; may be first confined to individual limbs but can encompass the entire shrub; leaves usually droop and turn brown yet remain attached to the stem; discolored, reddish-brown cankers appear as flattened areas on killed stems or branches.	• prune and remove symptomatic twigs or branches back to healthy wood when bark is dry; • avoid wounds and drought stress since the fungus is more aggressive on plants that have been predisposed by drought or winter injuries.	No chemical control is suggested.
Fungal Leaf Spots *(Alternaria, Phyllosticta)* p. 42	Circular, brown spots develop on leaves during wet weather; some leaf drop may occur when infection is heavy; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • provide good air circulation and avoid overhead watering; • spraying is usually not necessary since the disease has no significant impact on plant health; on specimen plants, fungicides can be applied when new growth emerges and repeated as necessary according to label directions.	azoxystrobin chlorothalonil chlorothalonil + iprodione chlorothalonil + thiophanate-methyl copper hydroxide iprodione mancozeb *potassium bicarbonate thiophanate-metyl

Pieris **(Japanese Andromeda, Pieris) cont'd**

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Phytophthora Root Rot *(Phytophthora* spp.*)* p. 354	Infected plants generally exhibit poor vigor; needles appear dull olive-green and eventually turn reddish-brown but usually remain attached to branches; branches and twigs die back; symptoms may be confined to individual branches or may develop progressively until the entire plant is involved; a diagnostic cinnamon-brown discoloration may be evident on the inner bark and cambium at the root/crown area; frequently more serious on shrubs where excess water is a persistent problem (e.g., clay soils, low areas).	• once infected, plants cannot be cured; • rogue and remove symptomatic plants and improve drainage; • avoid excessive irrigation and maintain vigor; • fungicides are not curative; healthy, uninfected plants adjacent to symptomatic plants can be protected with fungicides applied according to label directions.	fosetyl-Al mefenoxam mono- and di- potassium salts of phosphorus acid phosphorous acid
Tip Dieback and Blight *(Phytophthora* spp.*)* p. 354	Leaves and terminal buds begin to discolor; leaves turn brown and droop; a diagnostic V-shaped, water-soaked discoloration may be evident on the leaves, usually beginning at the point of petiole attachment to the leaf lamina; browning of the petiole often continues as the fungus-like organism moves into the twig; girdling cankers may form on twigs and branches and result in dieback.	• prune and remove affected tips well below obvious symptoms; • avoid excessive vigor; • avoid overhead irrigation; • fungicide sprays can be applied according to label directions when new shoots are growing.	chlorothalonil chlorothalonil + iprodione chlorothalonil + thiophanate-methyl copper hydroxide fosetyl-Al mancozeb mefenoxam

Pinus (Pine)

Disease *(Pathogen/Cause)*	Diagnostic Symptoms	Management	Materials
Armillaria Root Rot *(Armillaria* spp. *complex)* p. 326	Also called shoestring root rot and honey mushroom rot; this disease is difficult to identify since aboveground symptoms appear as general and progressive decline that leads to the eventual death of trees; trees can die singly or in groups; trees under environmental or site-related stresses are particularly susceptible; on conifers, excessive resin production at points of infections or at the bases of trees can be important symptoms of infection; the diagnostic black strands of the fungus called rhizomorphs (shoestrings) are usually not present on conifers; signs of the infection includes white fans of fungal growth with "mushroomy" odors under the bark and the occasional growth of honey mushrooms at the base of infected trees in autumn; the fungus can persist in stumps and large, woody roots for as long as 30 years; refer to fact sheet for more detailed information.	• maintain tree vigor; • avoid any unnecessary stresses, esp. drought stress; • avoid planting susceptible trees in a site where this disease has been confirmed; • if replanting in the site, the stump and all woody roots greater than ½ inch in diameter should be removed.	No chemical control is suggested.
Brown Spot Needle Blight *(Mycosphaerella dearnessii)* p. 26	Symptoms appear as reddish-brown, resin-soaked spots on needles in summer; affected needles turn yellow and eventually turn brown from the tips back; black fruiting structures of the fungus can be seen in infected spots during the fall; infected needles usually drop in fall; Austrian, Japanese black, Scots, mugo, and Italian stone pine are particularly susceptible; easily confused with other needlecasts.	• rake and remove fallen needles; • provide adequate spacing for good air circulation; • maintain vigor; • fungicide sprays can be applied when new growth emerges in spring and repeated as necessary according to label directions.	chlorothalonil chlorothalonil + iprodione chlorothalonil + thiophanate-methyl copper hydroxide mancozeb mancozeb + copper hydroxide thiophanate-methyl

Pinus (Pine) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Dooks Needle Blight [formerly Canavirgella Needlecast] *(Lophophacidium dooksii)* p. 50	This new disease of white pine for Connecticut was first identified in 1998; infected trees appear distinctly reddish-brown in late July and early August; symptoms are usually confined to current-season needles; tips of infected needles initially appear yellowish-tan and develop a distinct reddish-brown color by late August; infected needles curl and fade to tan or gray the following spring; diagnostic characteristics are: not all needles within a fascicle are infected and individual needles within a fascicle usually exhibit differing amounts of symptomatic tissue; frequently confused with acute ozone injury and other needlecast diseases; laboratory examination is usually required for definitive identification; refer to fact sheet for more detailed information.	• rogue and remove heavily infected trees; • provide adequate spacing for good air circulation; • maintain vigor; • fungicide sprays are usually not necessary; however, for new transplants or trees weakened by stress, chemical control may be beneficial; fungicides can be applied when new growth emerges and repeated as necessary according to label directions.	chlorothalonil copper hydroxide mancozeb mancozeb + copper hydroxide

Pinus **(Pine) cont'd**

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Cenangium Blight *(Cenangium)* p. 210	Random, "flagged" branches are early indicators of disease; symptoms include twig blight, branch dieback, and thinning of the canopy; trees can be significantly disfigured; outbreaks are often associated with severe winter weather, especially when it follows a mild autumn; brown needles drop prematurely, right after branches are killed; diagnostic symptoms include a sharp delineation between brown, dead cambium and inner bark and healthy tissues; yellowish-tan to brown, blister-like clusters of fruiting structures of the fungus are sometimes seen erupting from dead branches.	• maintain vigor; • prune and remove infected limbs as soon as symptoms appear; • cuts should be made several inches below visible symptoms when the bark is dry; • avoid unnecessary stress.	No chemical control is suggested.
Cyclaneusma Needlecast *(Cyclaneusma)* p. 54	Symptoms first appear as yellowish-green spots that gradually enlarge into bands until entire needles appear yellow; diagnostic symptoms include drop of straw-colored, second-year needles in autumn; distinct brown bands appear on infected needles of Scots pine; under conditions of high moisture, longitudinal, elliptical splits with creamy-tan fruiting structures of the fungus develop in the epidermis; heavily infected trees have only current-season needles; needles of all ages are susceptible; Austrian and mugo pines are particularly susceptible; easily confused with other needlecasts.	• rogue and remove heavily infected trees; • provide adequate spacing for good air circulation; • maintain vigor; • fungicide sprays can be applied when there is approx. 1½ inches of new growth and repeated in mid-May, mid-June, mid-August, and mid-October.	chlorothalonil chlorothalonil + iprodione chlorothalonil + thiophanate-methyl copper hydroxide mancozeb mancozeb + copper hydroxide thiophanate-methyl

Pinus (Pine) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Diplodia Blight [Sphaeropsis Tip Blight] (*Diplodia pinea*) p. 130	Tip blight results from infection of newly emerging buds and shoots; infected buds or shoots usually stop growing before or during needle elongation and needles are frequently stunted and short; infected tissues are straw-colored and have excessive resin flow; usually kills only current-season buds and shoots and second-year cones, but can cause significant dieback on stressed trees; black fruiting structures of the fungus may be visible at the base of needles and on cones; symptoms may be distributed uniformly throughout the canopy or concentrated in lower branches; drought-stressed trees are particularly susceptible; many pines are susceptible but two- and three-needled pines (e.g., Austrian and black pine) are highly susceptible; refer to fact sheet for more detailed information.	• prune and remove blighted twigs, branches, and cones during dry weather in autumn; • maintain tree vigor; special attention should be given to watering during periods of drought; • fungicide sprays can be applied at budbreak and repeated 2-3 times at label intervals.	chlorothalonil + thiophanate-methyl copper hydroxide copper sulphate pentahydrate mancozeb mancozeb + copper hydroxide *potassium bicarbonate propiconazole thiophanate-methyl triadimefon

Pinus (Pine) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Dothistroma Needle Blight [Red Banded Needle Blight] *(Dothistroma)* p. 28	Water-soaked spots or bands that turn yellow to reddish-brown appear on needles anytime from spring to fall; sharp lines mark the transition from green to discolored tissues; some swelling may occur in symptomatic bands on the needles; when the reddish-brown bands encircle the needles, the tips of the needles die but needle bases usually remain green; small, black fruiting bodies of the fungus break through the epidermis in symptomatic regions of the needles; diseased needles drop prematurely; Austrian, mugo, and Scots pines are particularly susceptible; easily confused with other needlecasts.	• rake and remove fallen needles as much as practical; • maintain vigor and provide adequate spacing for good air circulation; • fungicide sprays can be applied when new growth first appears and repeated for several applications at label intervals.	chlorothalonil chlorothalonil + iprodione *copper hydroxide copper sulphate pentahydrate mancozeb mancozeb + copper hydroxide
Lophodermium Needlecast *(Lophodermium)* p. 54	Infection is evident as needles first turn reddish-brown and eventually straw-colored by July; during the following winter, infected needles brown and drop; diagnostic, football-shaped fruiting structures of the fungus may be visible with a hand lens in the browned needles; two- and three-needled pines are most susceptible (e.g., Austrian, Scots, red);easily confused with other needlecasts.	• rogue and remove heavily infected trees; • provide adequate spacing for good air circulation; • maintain vigor; • fungicide sprays can be applied from July until October at label intervals.	chlorothalonil chlorothalonil + iprodione chlorothalonil + thiophanate-methyl copper hydroxide mancozeb mancozeb + copper hydroxide

Pinus (Pine) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Phytophthora Root Rot *(Phytophthora* spp.*)* p. 354	Infected trees generally exhibit poor vigor; needles appear dull olive-green and eventually turn brown but usually remain attached to branches; branches and twigs die back; symptoms may be confined to individual branches or may develop progressively until the entire tree is involved; excessive resin is sometimes visible on the bark at the base of the tree; a diagnostic cinnamon-brown discoloration may be evident on the inner bark and cambium at the root/crown area; frequently more serious on trees in sites where excess water is a persistent problem (e.g., clay soils, low areas).	• once infected, trees cannot be cured; • rogue and remove symptomatic trees and improve drainage; • avoid excessive irrigation and maintain vigor; • healthy, uninfected trees adjacent to symptomatic trees can be protected with fungicides applied according to label directions.	fosetyl-Al mefenoxam mono- and di-potassium salts of phosphorus acid phosphorous acid
Pine-Pine Gall Rust *(Endocronartium harknessii)* p. 304	This autoecious rust fungus infects many two- and three-needled pines (e.g., Scots pine is highly susceptible); fairly high incidences of this disease have been observed in recent years; symptoms include globose or pear-shaped, woody galls on branches and occasionally on the main stem; galls are perennial and enlarge from year to year, eventually causing the branches to die; severely infected, established trees can be disfigured; fruiting structures of the fungus break through the surface of existing galls and yellowish-orange spores are carried by wind and splashing rain to tender, elongating shoots.	• maintain vigor; • prune and remove infected branches back to healthy wood when bark is dry; • rogue and remove heavily infected trees to reduce the inoculum.	No chemical control is suggested.

Pinus (Pine) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Pine Wood Nematode *(Bursaphelenchus)* p. 436	Early symptoms are inconspicuous and include arrested or slowed growth and off-colored needles; trees commonly die abruptly in mid- to late summer; needles usually remain attached to the dead branches; the nematode is transmitted by wood-boring beetles (*Monochamus* sp.); possibly a complex involving as yet unidentified factors; trees under site-related and environmental stresses are more susceptible; branch or trunk "cookies" are necessary for identification.	• maintain vigor; • remove and destroy symptomatic trees.	No chemical control is suggested.
Pitch Canker *(Fusarium)* p. 188	Infected tissues have excessive resin flow associated with sunken, discolored lesions that girdle twigs, small branches, and trunks; diseased bark appears dark-red and the wood underneath is also discolored; shoot and branch dieback are usually most obvious from late autumn to early spring; needles may be glued together from excessive resin; wounds from insect activities, weather (hail, high winds), and mechanical injuries (poor pruning) are important for infection.	• maintain vigor; • prune and remove infected limbs as soon as symptoms appear; • cuts should be made several inches below visible symptoms; • avoid unnecessary wounding by careful cultural practices and insect control.	No chemical control is suggested.

Pinus (Pine) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Ploioderma Needlecast *(Ploioderma)* p. 48	Reddish-brown spots develop on 1-year-old needles during the late winter and early spring following summer infection; initial symptoms appear as yellow spots and bands that gradually turn brown; by late spring these bands appear straw-colored and, in some cases, the base of the needle remains green; fruiting structures of the fungus appear as black splits in the epidermis; whole needles may drop prematurely or symptomatic tips will break off leaving part of the needle attached to the tree; easily confused with other needlecasts.	• space trees to allow for good air circulation; • rake and remove fallen needles; • maintain tree vigor; • fungicide sprays can be applied when shoots are ½ -1 inch long and repeated at label intervals.	chlorothalonil copper hydroxide mancozeb mancozeb + copper hydroxide
Procerum Root Disease *(Leptographium)* p. 228	Also known as white pine root decline; this fungus infects the inner bark and sapwood of the roots and lower trunk of white pine; although most serious on white pine, it can also kill Scots and Austrian pines; in spring, trees that have been infected for several years show delayed bud break and reduced candle elongation; mature foliage then fades, droops, and turns brown; mortality appears to be at random with a few trees dying each year; resin flow is visible at the tree base and is associated with a girdling, chocolate brown to dark olive-brown canker under the bark; weevils and other bark-infesting insects may serve as vectors for this disease.	• avoid planting eastern white pine on wet sites; trees planted on wet sites seem to be more susceptible to the fungus; excessively dry sites also seem to predispose trees to attack; • remove and destroy infected trees including stumps, if possible; • do not replant eastern white pine among the stumps of recently killed trees; • if trees need to be replaced, do not plant a pine; use arborvitae or spruce.	No chemical control ia suggested.

Pinus (Pine) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Sirococcus Tip Blight *(Sirococcus)* p. 118	Symptoms first appear on succulent shoots and 1-year-old twigs; the fungus attacks at needle bases, girdles the shoot, and results in tip dieback; affected tips turn brown, drop needles, and often develop a characteristic crook or droop; pinpoint, brown fruiting structures may be visible along the stems of dead shoots; affected tips can appear at random in the canopy; refer to fact sheet for more detailed information.	• prune and remove infected shoots when bark is dry; • rogue and remove heavily infected trees; • maintain vigor; • Austrian and white pine are less susceptible than other species; • fungicide sprays can be applied when needles are ½ inch long and repeated 2-4 times at label intervals until needles are fully expanded.	azoxystrobin chlorothalonil chlorothalonil + iprodione mancozeb mancozeb + copper hydroxide propiconazole thiophanate-methyl triadimefon

Pinus (Pine) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
White Pine Blister Rust *(Cronartium ribicola)* p. 292	This historically important disease is still endemic on eastern white pine in many parts of Connecticut; a new twist recently developed with the discovery of a new strain of the fungus identified in CT, NH, NY, and several Canadian provinces; this strain has genetic mutations that overcome the gene that controls resistance in immune currants, which are widely grown in many states; with this breakdown in resistance, the fungal life cycle is now able to be completed and increases the threat of increased occurrence of disease in pine; the fungus requires alternate hosts (*Ribes* spp., currants and gooseberries) to complete its life cycle— if resistant or immune cultivars are planted the cycle is not completed; symptoms on pine include general thinning, dieback, and decline in the canopy associated with girdling cankers; cankers appear sunken and discolored and are often covered with resin; at certain times of the year, pustules or blisters develop in the cankers and break open to reveal powdery, yellow spores; cankers that girdle the main trunk result in tree death.	• eradicate alternate hosts (e.g., gooseberries, wild currants) within 500 feet; • scout for branch cankers and prune any visible cankers at least 4-6 inches below visible symptoms when bark is dry; • young cankers on the main trunk can sometimes be successfully removed by cutting out the canker and 2-4 inches of bark around the visible canker; • maintain vigor.	No chemical control is suggested.

Pinus (Pine) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Winter Injury/Drying *(Abiotic)* p. 432	Symptoms include tipburn, chlorotic mottling or uniform yellowing of needles, and tip or branch dieback; damage often appears on one side of the tree or only on one branch, usually the side facing prevailing winds; one-third to one-half of each needle is often browned; refer to fact sheet for more detailed information.	• maintain vigor; • trees, especially new transplants, benefit from a deep soaking prior to the ground freezing.	No chemical control is suggested.

Platanus (London Plane, Sycamore)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Anthracnose *(Apiognomonia)* p. 102	Large, brown patches develop along veins or at leaf margins as the leaves expand in spring; this often results in extensive tattering and distortion; severely infected leaves drop and refoliation usually occurs; tender shoots are often infected and die; blighting of shoots, dieback, cankers, and deformity of branches may also occur as the fungus infects young shoots and twigs; repeated defoliation significantly weakens trees as evidenced by loss of vigor, dieback, and thinning of the canopy, and increased susceptibility to winter injury and insects (e.g., borers); most severe during cool, wet springs; sycamore is more susceptible than London and Oriental planes; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • prune and remove infected limbs or tips when possible; • maintain vigor; • select resistant cultivars of London plane (e.g., 'Bloodgood,' 'Columbia,' 'Liberty'); • fungicide sprays usually aren't necessary or practical but can be applied at budbreak and repeated at label intervals until leaves are fully expanded.	carbendazim chlorothalonil chlorothalonil + iprodione chlorothalonil + thiophanate-methyl copper hydroxide *copper sulfate copper sulphate pentahydrate mancozeb mancozeb + copper hydroxide mancozeb + thiophanate-methyl propiconazole thiabendazole thiophanate-methyl
Canker and Dieback *(Botryosphaeria)* p. 120	Twigs and branch tips wilt and die back; may be first confined to individual limbs but can encompass the entire shrub; leaves usually droop and turn brown yet remain attached to the stem; discolored, brown cankers appear as flattened areas on killed stems or branches; symptoms are often confused with those of anthracnose.	• prune and remove symptomatic twigs or branches back to healthy wood when bark is dry; • avoid wounds and drought stress since the fungus is more aggressive on plants that have been weakened by drought or winter injuries.	No chemical control is suggested.

Platanus (London Plane, Sycamore) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Canker Stain *(Ceratocystis)* p. 234	Although considered to be the most important disease of London plane, very few samples have been diagnosed in recent years; symptoms appear as elongated, brown or black discolorations that develop on the bark of branches or trunks; these develop into flattened cankers; numerous cankers can be found on an individual branch or trunk and can coalesce and girdle the affected tissues; infected phloem and cambium appear black and the wood underneath is stained bluish-black; old cankers crack to reveal the discoloration; when the trunk is girdled, trees decline and die.	• avoid wounding; • all pruning equipment should be clean and routinely disinfested during use; • rogue and remove heavily infected trees.	No chemical control is suggested.
Leaf Spots *(Mycosphaerella, Phyllosticta)* p. 22	Irregular to circular spots develop on leaves in mid- to late summer; lesions are dark-brown and have indefinite margins; heavily infected leaves yellow and drop prematurely; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • spraying is usually not necessary since the disease has no significant impact on tree health; however, on specimen or newly transplanted trees, fungicides can be applied as new growth emerges in spring and repeated as necessary according to label directions.	chlorothalonil chlorothalonil + thiophanate-methyl mancozeb mancozeb + copper hydroxide thiophanate-methyl

Platanus (London Plane, Sycamore) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Powdery Mildew *(Erysiphe)* p. 8	Heavy coating of whitish-gray, powdery growth usually on upper surfaces of leaves; some distortion of leaves and young shoots may occur if infection is early in the season; London plane trees are particularly susceptible; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • spraying is usually not necessary since the disease has no significant impact on tree health; on specimen trees, fungicides can be applied as soon as symptoms are evident and repeated as necessary.	chlorothalonil + thiophanate-methyl mancozeb + copper hydroxide myclobutanil *sulfur thiophanate-methyl triadimefon

Populus (Cottonwood, Poplar)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Canker *(Cryptodiaporthe)* p. 154	Early symptoms aren't very obvious and include dieback of scattered twigs associated with cankers; elongate, dark, sunken cankers can form on the bark of twigs, branches, or the main trunk; the bark and cambium are killed and the sapwood is discolored; extensive dieback occurs when cankers girdle twigs or branches; trees under environmental and site-related stresses are most susceptible; Lombardy poplar is highly susceptible.	• prune and remove infected limbs when bark is dry; • rogue and remove heavily infected trees; • maintain vigor since weakened trees are highly susceptible.	No chemical control is suggested.
Fungal Leaf Spots *(Marssonina)* p. 82	Brown spots or blotches develop on leaves and pustules or eruptions develop on petioles; in wet weather, infections can be heavy enough to cause extensive defoliation by early August; if this occurs, trees often regrow but the new growth is not winter-hardy and dies back by the following spring; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • fungicide sprays can be applied when new growth emerges in spring and repeated at label intervals until fully mature; • maintain vigor.	azoxystrobin chlorothalonil chlorothalonil + iprodione chlorothalonil + thiophanate-methyl mancozeb mancozeb + copper hydroxide thiophanate-methyl
Leaf Blister *(Taphrina)* p. 4	Irregular, chlorotic blisters develop on upper leaf surfaces during late spring or summer; a yellow "bloom" is often visible on the undersurface of the blister.	• maintain vigor; • spraying is usually not necessary since the disease has no significant impact on tree health; on specimen or newly transplanted trees, fungicide sprays can be applied before buds begin to swell in spring.	chlorothalonil + iprodione chlorothalonil + thiophanate-methyl mancozeb

Populus (Cottonwood, Poplar) cont'd

Disease *(Pathogen/Cause)*	Diagnostic Symptoms	Management	Materials
Powdery Mildew *(Erysiphe)* p. 8	White to grayish, powdery growth on leaves, usually first evident on upper leaf surfaces but can occur on both surfaces of leaves; develops fairly late in the season; some premature fall coloration and leaf drop may occur; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • avoid excessive fertilization since tender, succulent leaves are more susceptible; • provide good air circulation around the tree; • spraying is usually not necessary since the disease has no significant impact on tree health; on specimen trees, fungicides can be applied as soon as symptoms are evident and repeated as necessary.	chlorothalonil + thiophanate-methyl copper sulphate pentahydrate mancozeb + thiophanate-methyl propiconazole *sulfur thiophanate-methyl triadimefon
Rust *(Melampsora* spp.*)* p. 284	Several species of fungi cause rust symptoms on poplar; small, bright yellow or orange pustules or blisters develop on upper or lower surfaces of leaves in late spring or summer; angular, chlorotic areas can also develop on the surface opposite the pustule; heavy infections result in premature leaf drop; these fungi overwinter on fallen poplar leaves; several of the alternate hosts of these fungi are Douglas-fir, pine, and larch; in spring, spores develop on fallen poplar leaves and infect emerging conifer needles; yellow pustules develop on these needles and spores produced on these infected needles infect tender poplar leaves.	• rake and remove fallen leaves; • provide good air circulation around the tree; • spraying is usually not necessary since the disease has no significant impact on tree health; on specimen trees, fungicides can be applied as new growth emerges in spring and repeated as necessary according to label directions.	mancozeb mancozeb + copper hydroxide myclobutanil propiconazole triadimefon

Prunus (Cherry, Flowering Cherry, Peach, Plum)

Disease *(Pathogen/Cause)*	Diagnostic Symptoms	Management	Materials
Bacterial Canker *(Pseudomonas syringae* pv. *syringae)* p. 368	Infected buds fail to open in spring; small, greasy-looking spots develop on newly emerged leaves and symptomatic leaves often turn brown; shoots appear blackened and cankers develop on branches or the main trunk; leaves on cankered branches wilt; under optimum conditions, cankers ooze; infected trees decline and die; particularly problematic on weakened trees	• prune and remove infected twigs 8-10 inches below visible symptoms; • disinfest tools between cuts; • maintain vigor but avoid excessive fertilization; • preventative sprays can be applied before and during shoot expansion and repeated as necessary; select the appropriate fungicide if harvesting fruit for consumption.	copper hydroxide copper sulphate pentahydrate
Black Knot *(Apiosporina morbosa)* p. 152	Distinctive, dark-brown to black charcoal-like swellings or knots develop on twigs or branches; they first appear as green swellings but gradually develop their diagnostic character; knots continue to enlarge from year to year and often become quite rough in appearance; significant dieback of branches and twigs can occur; girdling knots on the main trunk kill trees; in late spring, knots are covered with pinkish-white spores of the fungus; most *Prunus* species have some level of susceptibility, but cherries and plums are highly susceptible; refer to fact sheet for more detailed information.	• prune and remove symptomatic tissues 6-8 inches below visible knots; • severely infected trees should be removed; • any unwanted *Prunus* species (e.g., wild plum, wild black cherry, chokecherry) in nearby woodlots should be removed to reduce inoculum (trees within 600 feet); • fungicide sprays can be applied when new growth emerges in spring and repeated at label intervals until fully mature; select the appropriate fungicide if harvesting fruit for consumption.	chlorothalonil mancozeb + copper hydroxide

Prunus (Cherry, Flowering Cherry, Peach, Plum) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Brown Rot/Shoot Blight *(Monilinia fructicola, M. laxa)* p. 76	Infected flowers collapse, turn brown, and are frequently covered with the fuzzy, tannish-brown growth of the fungus; tender twigs, shoots, and leaves may shrivel and appear blighted due to girdling cankers (often confused with fire blight); ripening fruit, if present, may shrivel and become covered with tan masses of the fungus; infected fruit may also mummify and persist on the tree into the winter; particularly severe during wet weather; refer to fact sheet for more detailed information.	• rake and remove mummified fruit; • prune and remove blighted or cankered twigs and limbs; • maintain vigor; • for ornamental trees, fungicide sprays can be applied at budbreak and repeated 2-4 times as necessary; early-season sprays, especially during bloom, are very important; • for trees grown for fruit production, susceptible varieties usually require a season-long fungicide program in order to harvest quality fruit; select the appropriate fungicide if harvesting fruit for consumption.	chlorothalonil chlorothalonil + iprodione chlorothalonil + thiophanate-methyl copper hydroxide copper sulfate mancozeb mancozeb + copper hydroxide propiconazole thiophanate-methyl
Gummosis *(Abiotic)* p. 358	Gummosis is associated with many factors including mechanical injury, winter injury, insect damage, and overfertilization; amber-colored gum is exuded from buds, twigs, branches, and trunks; deposits collect beneath the bark, eventually break, and are often visible at branch crotches and on the main trunk.	• maintain vigor and avoid injuries; • control insects.	No chemical control is suggested.
Leaf Curl *(Taphrina deformans)* p. 4	As leaves emerge in spring, they appear thickened and have blister-like distortions that are often reddish; in some cases, succulent shoots may also be deformed; heavily symptomatic leaves brown and drop prematurely; trees usually refoliate with normal leaves shortly thereafter; refer to fact sheet for more detailed information.	• maintain vigor; • fungicide sprays can be applied before buds begin to swell in spring; select the appropriate fungicide if harvesting fruit for consumption	chlorothalonil chlorothalonil + thiophanate-methyl mancozeb + copper hydroxide

Prunus (Cherry, Flowering Cherry, Peach, Plum) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Leaf Spot [Coccomyces Leaf Spot] *(Blumeriella jaapii)* p. 80	Discrete, small, dark-purple spots appear on the leaves when they are fully expanded; in wet weather, white masses of conidia are visible on undersides of infected leaves; the spots can drop out and give the leaves a shot-holed appearance; this is usually followed by widespread yellowing and drop of the leaves; particularly severe after cool, wet spring weather; very heavy in 2006.	• maintain vigor; • rake and remove fallen leaves; • fungicide sprays can be applied when new growth emerges in spring and repeated at label intervals until fully mature; select the appropriate fungicide if harvesting fruit for consumption.	chlorothalonil + thiophanate-methyl mancozeb mancozeb + copper hydroxide myclobutanil propiconazole thiophanate-methyl
Powdery Mildew *(Podosphaera)* p. 8	White to grayish, powdery growth on leaves, usually first evident on the upper leaf surfaces; typically develops fairly late in the season; however, when infection occurs early in the season when tissues are young, some distortion and twisting of leaves and tips can occur; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • provide good air circulation around the tree; • spraying is usually not necessary since the disease has no significant impact on tree health; on specimen trees, fungicides can be applied as soon as symptoms are evident and repeated as necessary according to label directions; select the appropriate fungicide if harvesting fruit for consumption.	azoxystrobin chlorothalonil chlorothalonil + thiophanate-methyl mancozeb + thiophanate-methyl *potassium bicarbonate propiconazole *sulfur thiophanate-methyl triadimefon trifloxystrobin

Prunus (Cherry, Flowering Cherry, Peach, Plum) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Winter Injury *(Abiotic)* p.498	Symptoms are variable and include dieback and shriveling of branches and twigs; symptoms are most evident in late winter or early spring as growth resumes; however, they can develop in early summer as a sudden and "unexplained" dieback and collapse; refer to fact sheet for more detailed information.	• maintain vigor; • prune and remove symptomatic tissues to minimize secondary invaders and opportunistic pests.	No chemical control is suggested.

Prunus (Cherry, Flowering Cherry, Peach, Plum) cont'd

Disease *(Pathogen/Cause)*	Diagnostic Symptoms	Management	Materials
X-disease (Prunus X-disease group of phytoplasmas) p. 400	X-disease is historically a serious problem for stone fruit in Connecticut but in recent years has been found in increasing frequency in landscape or backyard trees; hosts includie peach, nectarine, sweet and sour cherry, and Japanese plum; the key reservoir host is chokecherry, *Prunus virginiana*; trees with X-disease usually appear normal at the start of the growing season although some trees may exhibit branch and twig dieback due to increased sensitivity to winter injury or may have slightly smaller leaves; by mid-summer, there is a sudden onset of symptoms; these may be on a single branch or the entire tree; leaves develop yellow or reddish, irregular water-soaked blotches and often roll upward longitudinally along the mid-vein; discolored areas become dry and brittle and the dead tissues drop out giving the leaf a tattered, shot-holed appearance; symptomatic leaves drop off, often leaving a characteristic cluster of leaves at the tip of the branches; trees with X-disease gradually decline since the disease is chronic and progressive due to the systemic distribution of the X-phytoplasma in the phloem; infected trees eventually die within 2-6 years depending upon the age of the tree at the time of infection; several species of phloem-feeding leafhoppers transmit this phytoplasma; refer to fact sheet for more detailed information.	• rogue and remove heavily infected trees; • maintain vigor; • remove chokecherry in the vicinity of stone fruits • antibiotic injections of oyxtetracycline are registered for non-bearing trees, but not encouraged.	No chemical control is suggested.

Pseudotsuga (Douglas-Fir)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Diplodia Blight [Sphaeropsis Tip Blight] *(Diplodia pinea)* p. 130	Tip blight results from infection of buds and shoots; infected buds and shoots usually stop growing before or during needle elongation and needles are frequently short; infected tissues are straw-colored; usually kills only current-season buds and shoots, but can cause significant dieback on trees under stress, especially under drought stress; black fruiting structures of the fungus may be visible on infected shoots; symptoms may be distributed uniformly throughout the canopy or concentrated in lower branches; refer to fact sheet for more detailed information.	• prune and remove blighted twigs and branches during dry weather in autumn; • maintain tree vigor with special attention to watering during periods of drought; • fungicide sprays can be applied at budbreak and repeated as necessary at label intervals until needles are fully expanded.	copper sulphate pentahydrate mancozeb *potassium bicarbonate propiconazole thiophanate-methyl

Pseudotsuga (Douglas-Fir) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Rhabdocline Needlecast *(Rhabdocline* spp.*)* p. 58	Yellow spots on one or both surfaces of 1-year-old needles first appear in late fall or early winter; spots gradually turn reddish-brown and can appear as distinct bands or encompass the entire needle; a diagnostic symptom is the sharp border between green and brown tissue; discolored needles are most conspicuous in early spring and heavily infected trees look scorched; in late spring, the epidermis of infected needles ruptures, usually in two longitudinal lines, and orangy-brown fruiting structures of the fungus can be seen with a hand lens; significant drop of infected needles occurs and symptoms are often most serious on lower branches where air circulation is poor; very heavy infections have been observed in landscape trees during the past few years; refer to fact sheet for more detailed information.	• maintain tree vigor; • rogue and remove heavily infected trees; • pay attention to site, especially with regard to air circulation; • provide adequate spacing and maintain good weed control for optimum air circulation; • seed sources vary in susceptibility (e.g., highly susceptible- 'Lincoln'; moderately susceptible- 'Santa Fe'; least susceptible- 'Shuswap'); • fungicide sprays can be applied when new growth is ½ inch long and repeated 2-4 times at label intervals until needles are fully expanded or conditions are no longer favorable for disease.	chlorothalonil chlorothalonil + iprodione chlorothalonil + thiophanate-methyl copper hydroxide mancozeb

Pseudotsuga (Douglas-Fir) cont'd

Disease *(Pathogen/Cause)*	Diagnostic Symptoms	Management	Materials
Swiss Needlecast *(Phaeocryptopus gaumanni)* p. 58	This needlecast has increased in severity and incidence throughout Connecticut in the past 5 years after many years of absence; symptoms develop on first- or second-year needles and are usually evident in late winter and early spring; infected needles are yellow or mottled and gradually turn brown; when needles are examined with a hand lens, two bands of round, black fruiting bodies can be seen on either side of the midrib; green needles can also be infected and serve as a source of inoculum; Swiss needlecast is often confused with "sooty mold," which is a superficial, unsightly, but non-pathogenic fungus that grows on the honeydew or excrement of insects; refer to fact sheet for more detailed information.	• maintain tree vigor; • rogue and remove heavily infected trees; • pay attention to site, especially with regard to air circulation; • fungicide applications can be made when new shoots are approximately 1-1½ inches long and again 3 weeks later; additional applications may be necessary in years with excessive rainfall.	chlorothalonil chlorothalonil + iprodione chlorothalonil + thiophanate-methyl mancozeb *potassium bicarbonate

Pyracantha (Firethorn)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Fire Blight *(Erwinia amylovora)* p. 376	Flowers wither and blacken; young twigs and branches die from the terminals back and appear as though “burned”; affected limbs frequently develop a characteristic shepherd's crook at the tip; dead leaves usually remain attached to the branch; sunken, discolored cankers may be evident on branches or the main trunk; refer to fact sheet for more detailed information.	• prune and remove infected branches at least 10-12 inches below visible symptoms when bark is dry; • carefully remove prunings to avoid spread; • disinfest tools between cuts; • avoid excessive nitrogen fertilization or vigor; • select cultivars with reported resistance (e.g., ‘Mojave,’ ‘Shawnee’).	No chemical control is suggested.
Scab *(Venturia inaequalis* f. sp. *pyracanthae)* p. 88	Circular, olive-black, velvety spots with feathery, diffuse margins develop on leaves, fruit, and young fruit stems; heavy infections result in leaf yellowing and significant defoliation in midsummer; infected fruit often crack and drop prematurely.	• rake and remove fallen leaves; • prune dead twigs and branches; • maintain vigor since repeated defoliation weakens trees; • resistant cultivars are available (e.g., *Pyracantha* ‘Firey Cascade’; *P. crenato-sessata*, ‘Yunan Firethorn,’ ‘Shawnee,’ ‘Rutgers,’ ‘Santa Cruz Prostata’); • chemical control is usually not necessary except for new transplants, young or specimen trees, or when defoliation has been heavy for several years; fungicide sprays can be applied at budbreak and repeated 2-3 times at label intervals.	chlorothalonil chlorothalonil + iprodione chlorothalonil + thiophanate-methyl copper hydroxide copper sulphate pentahydrate mancozeb mancozeb + copper hydroxide mancozeb + thiophanate-methyl myclobutanil *potassium bicarbonate propiconazole thiophanate-methyl

Pyrus (Pear)

Disease *(Pathogen/Cause)*	Diagnostic Symptoms	Management	Materials
Fire Blight *(Erwinia amylovora)* p. 376	Flowers wither and blacken; young twigs and branches die from the terminals back and appear as though “burned”; affected limbs frequently develop a characteristic shepherd's crook at the tips; dead leaves usually remain attached to the branch; sunken, discolored cankers may be evident on branches or the main trunk; symptoms often develop in a relatively short period of time; resistance is available; e.g., Bradford pear (*Pyrus calleryana* ‘Bradford’) is reported to be tolerant; refer to fact sheet for more detailed information.	• avoid excessive nitrogen fertilization or vigor; • overwintering cankers should be pruned and removed during the winter; make cuts at least 10-12 inches below visible symptoms when bark is dry; • during the growing season, prune and remove infected branches as soon as they develop; make cuts at least 10-12 inches below visible symptoms when bark is dry; • carefully remove prunings to avoid spread; • disinfest tools between cuts; • recent studies with infected fruit trees have shown that this old method of cutting 8-10 inches below visible symptoms of growing-season blight strikes has certain limitations; new research has shown that bacteria can sometimes be found as far as 9 feet beyond visible symptoms on highly susceptible trees; they suggest that cuts on symptomatic shoots should be made back to 2-year or older wood and at least 8-12 inches below the visible symptoms; • continued on next page;	*copper hydroxide copper sulphate pentahydrate mancozeb + copper hydroxide

Pyrus (Pear) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Fire Blight (Cont'd)		• these cuts often leave a 4-5 inch naked stub above the next leaf or branch, so this method has been called the "ugly stub" method; cuts should be made when the bark is dry; the presence of "ugly stubs" in the tree will flag infection sites for follow-up with winter pruning; • preventative copper sprays can be applied to the bark before growth emerges in spring; additional applications may be necessary to protect newly emerging shoots until flowering; select the appropriate product if harvesting fruit for consumption; • although streptomycin is registered, it is discouraged for ornamental use to reduce the potential for resistance development in the bacterial populations (resistance to streptomycin is widespread in many large fruit producing regions of the U.S.).	
Leaf Blister *(Taphrina)* p. 4	Irregular, chlorotic blisters develop on upper leaf surfaces during late spring or summer; a whitish "bloom" is often visible on the undersurface of the blisters; infected leaves usually remain attached to the tree.	• maintain vigor; • spraying is usually not necessary since the disease has no significant impact on tree health; on specimen or newly transplanted trees, fungicide sprays can be applied before buds begin to swell in spring.	chlorothalonil mancozeb

Pyrus (Pear) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Leaf Spot [Fabraea Leaf Spot] *(Diplocarpon mespili)* p. 78	Discrete, circular, dark-brown spots develop on leaves; when numerous, they coalesce and form large, dead blotches; fruiting structures of the fungus develop under the cuticle of lesions and give the spots a blister-like appearance; significant early leaf drop can occur; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • provide good air circulation around the tree and avoid overhead watering; • maintain tree vigor; • spraying is usually not necessary since the disease has no significant impact on tree health; on specimen trees, fungicides can be applied as new growth emerges and repeated as necessary according to label directions; • select the appropriate fungicide if harvesting fruit for consumption.	copper hydroxide mancozeb thiophanate-methyl
Pear Trellis Rust *(Gymnosporangium sabinae)*	New to CT in 2012, primary hosts include ornamental (*Pyrus calleryana*) and orchard (*Pyrus communis*) pear trees; symptoms begin as yellowish-orange spots visible on the upper leaf surfaces early in the season; spots thicken and develop into diagnostic reddish-orange spores structures visible on the lower surface of the leaf by late summer; these include protruding, acorn-shaped structures with open, trellis-like sides (this feature gives the disease its common name); similar to other Gymnsporangium rust, this fungus requires alternate hosts (*Juniperus* spp.) to complete its life cycle; refer to fact sheet for more detailed information;	• if possible, eliminate the alternate hosts (any red cedar or juniper species) within a one-mile radius; • prune and remove spindle-shaped galls from juniper in early spring; • for specimen ornamental pear trees, fungicide sprays can be applied when new growth is emerging in spring and repeated 2-3 times at label intervals; this is usually when the gelatinous, small orange structures are visible on the juniper hosts (usually mid-May); • select the appropriate fungicide if harvesting fruit for consumption.	myclobutanil triadimefon

Pyrus (Pear) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Powdery Mildew *(Podosphaera)* p. 8	White to grayish, powdery growth develops on leaves; this is usually first evident on the upper leaf surfaces but can occur on both leaf surfaces; some premature leaf coloration can occur; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • provide good air circulation around the tree; • spraying is usually not necessary since the disease develops mid to late in the season and has no significant impact on tree health; on specimen trees, fungicides can be applied as soon as symptoms are evident and repeated as necessary; • select the appropriate fungicide if harvesting fruit for consumption.	azoxystrobin myclobutanil *potassium bicarbonate thiophanate-methyl triadimefon
Scab *(Venturia pirina)* p. 88	Circular, olive-black, velvety spots with feathery, diffuse margins develop on leaves, fruit, and young fruit stems; heavy infections result in leaf yellowing and significant defoliation in midsummer; infected fruit often crack and occasionally drop; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • maintain tree vigor since repeated defoliation weakens trees; • chemical control is usually not necessary except for new transplants, young or specimen trees, or when defoliation has been heavy for several years; fungicide sprays can be applied at budbreak and repeated 2-4 times at label intervals; early-season sprays are very important; • select the appropriate fungicide if harvesting fruit for consumption.	chlorothalonil chlorothalonil + iprodione copper hydroxide copper sulphate pentahydrate mancozeb mancozeb + thiophanate-methyl myclobutanil propiconazole thiophanate-methyl

Quercus (Oak)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Anthracnose *(Apiognomonia)* p. 100	Irregular, necrotic spots that are tan and papery in appearance develop on newly emerging leaves in wet weather; spots are often so numerous that they coalesce and leaves appear blighted; some leaf distortion also occurs when margins are infected; as leaves reach full size they become resistant; heavily infected leaves drop and defoliation can occur; twigs with overwintering infections may die; white oak is most susceptible; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • prune and remove infected twigs; • maintain vigor; • fungicide sprays are usually not practical or necessary except for new transplants, young or specimen trees, or when defoliation has been heavy for several years; fungicide sprays can be applied at budbreak and repeated 2-3 times at label intervals.	azoxystrobin chlorothalonil chlorothalonil + iprodione chlorothalonil + thiophanate-methyl copper sulphate pentahydrate mancozeb mancozeb + copper hydroxide thiophanate-methyl

Quercus (Oak) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Armillaria Root Rot *(Armillaria* spp. *complex)* p. 326	One of the most common diseases of oak in Connecticut; also called shoestring root rot and honey mushroom rot; this disease is difficult to identify since aboveground symptoms appear as general and progressive decline that leads to the eventual death of trees; trees can die singly or in groups; trees under environmental or site-related stresses are particularly susceptible; diagnostic signs of infection include black strands of the fungus called rhizomorphs (shoestrings) on the surface of the bark or at the base of infected trees, white fans of fungal growth with "mushroomy" odors under the bark, and the occasional growth of honey mushrooms at the base of infected trees in autumn; narrow, black lines are often evident in infected wood; the fungus can persist in stumps and large, woody roots for as long as 30 years.	• maintain tree vigor; • avoid any unnecessary stresses, esp. drought stress; • avoid planting susceptible trees in a site where this disease has been confirmed; • if replanting in the site, the stump and all woody roots greater than ½ inch in diameter should be removed.	No chemical control is suggested.

Quercus (Oak) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Bacterial Wetwood and Slime Flux *(Bacteria and yeasts)* p. 384	This disease complex is usually not an important problem for landscape trees but it can cause unsightly and unpleasant conditions for homeowners; wet streaks are visible on the outer bark of the main trunk where liquids seep out of cracks or fissures in the bark; depending on the organisms responsible, the ooze can be bubbly and amber and have a foul odor or it can be colorless and have an "alcoholic," fermentative odor; oozing can be extensive at certain times of the year; the slime can be toxic to the cambium; when these tissues are killed, additional cracks can develop; some discoloration of the wood may occur but there are usually no symptoms in the canopy.	• maintain vigor; • wash off oozing liquid with a stiff spray of water.	No chemical control is suggested.
Biscogniauxia (Hypoxylon) Canker *(Biscogniauxia)* p. 200	Initial symptoms are nonspecific and include yellowing or wilting of leaves and random branch dieback; the fungus is an opportunistic pathogen that readily attacks weak or stressed trees, especially heat and drought-stressed trees; as it colonizes weakened branches or limbs, it decays the inner bark and sapwood and forms a tan or silvery-gray stroma; these are visible as the outer bark sloughs off and appear as characteristic smooth strips several feet long; stroma turn from tan to black with age.	• prune and remove infected twigs or branches; • maintain vigor; • avoid unnecessary stresses.	No chemical control is suggested.

Quercus (Oak) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Bleeding Canker *(Phytophthora* spp.) p. 354	Primary symptoms include oozing of reddish-brown fluid from fissures or cracks in the bark; these are usually centered over diffuse cankers; infected inner bark, cambium, and sapwood appear distinctly reddish-brown; some dieback of branches and thinning of the canopy can occur; can result in tree death; quite prevalent in landscape trees in 2006 growing season.	• maintain tree vigor by attention to irrigation, soil compaction; • mildly infected trees have occasionally been reported to recover; • rogue and remove heavily infected trees to reduce the potential of spread to nearby trees; • recent trials have demonstrated anecdotal success with directed basal bark sprays and injections of mono- and di-potassium salts of phosphorus acid.	mono- and di-potassium salts of phosphorus acid phosphorus acid
Botryosphaeria Canker *(Botryosphaeria)* p. 120	Random dieback of branches and limbs; usually associated with sunken cankers in which black fruiting structures of the fungus may be visible; problematic on trees weakened by other factors such as drought.	• prune affected limbs back to healthy wood as soon as detected and when bark is dry; • avoid wounding and unnecessary stress such as drought stress; • maintain tree vigor.	No chemical control is suggested.
Leaf Blister *(Taphrina caerulescens)* p. 4	Pale-green spots ¼ - ¾ inch in diameter appear on newly expanding leaves; spots expand and develop into blister-like bulges on the leaves; as the blisters age they become necrotic; trees with heavy infections usually appear off-colored since the symptomatic leaves remain attached to the tree.	• maintain vigor; • spraying is usually not necessary; however, on specimen or newly transplanted trees, fungicide sprays can be applied before buds begin to swell in spring.	chlorothalonil chlorothalonil + iprodione chlorothalonil + thiophanate-methyl mancozeb

Quercus (Oak) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Oak Wilt *(Ceratocystis fagacearum)* p. 238	**TO DATE, THIS DISEASE HAS NOT BEEN CONFIRMED IN CONNECTICUT; IT IS LISTED HERE FOR INFORMATION ONLY;** no species of oak of immune to this disease, although red oak are killed more often and more quickly than white oak; symptoms vary with species, but include brown-bronze discoloration of leaves, water-soaking, and wilt; damage often starts at the tip and moves towards the base of the leaf; heavy defoliation occurs, although some infected trees hold onto symptomatic leaves until fall; some trees can be killed within 1-2 months after the onset of symptoms; fungal mats are often visible on the trunks of red oak, and they push out and crack the bark; since this is wilt disease, vascular discoloration is visible in the xylem; the fungus is spread through root grafts and by sap beetles.	• avoid pruning during high risk periods (April, May and June); safe time to prune is November- March; • install mechanical barriers to prevent and disrupt root grafts; • dead trees should be removed promptly; • do not move firewood or felled infected trees from area; • fungicide injections of high value trees can be applied to prevent infections.	propiconazole
Powdery Mildew *(Erysiphe)* p. 8	White to grayish, powdery growth on leaves, usually first evident on upper leaf surfaces but can occur on both surfaces of leaves; develops fairly late in the season; some premature fall coloration and leaf drop may occur; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • avoid excessive fertilization since tender, succulent leaves are more susceptible; • provide good air circulation around the tree; • spraying is usually not necessary since the disease has no significant impact on tree health; on specimen trees, fungicides can be applied as soon as symptoms are evident and repeated as necessary.	azoxystrobin chlorothalonil + thiophanate-methyl mancozeb + thiophanate-methyl myclobutanil propiconazole thiophanate-methyl triadimefon

Quercus (Oak) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Scorch *(Xylella fastidiosa)* p. 386	**TO DATE, THIS DISEASE HAS NOT BEEN CONFIRMED IN CONNECTICUT; IT IS LISTED HERE FOR INFORMATION ONLY;** leaves develop scorch symptoms in early to midsummer; leaf margins first appear chlorotic and discolor to drab green and then to brown; a distinctive reddish band often develops at the margin between symptomatic and green tissues; leaves usually remain attached to the tree; symptoms may appear on one or two branches and gradually increase from year to year; symptoms are often confused with abiotic scorch; with *Xylella*, symptoms first appear on older leaves and progress toward new growth; with abiotic scorch, symptoms usually first appear at tips of branches and move inward; definitive diagnosis requires laboratory tests; samples from any suspicious trees should be submitted for analysis.	• maintain vigor; • prune symptomatic portions to reduce secondary invaders and opportunistic pests • antibiotic injections of oyxtetracycline are registered but not encouraged.	No chemical control is suggested.

Quercus (Oak) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Tubakia Leaf Spot (Actinopelte Leaf Spot) *(Tubakia dryina)* p. 44	Symptoms are often confused with anthracnose; they appear in late summer and early fall; circular lesions about ¼ -½ inch in diameter are initially water-soaked but then turn reddish brown; spots may coalesce to form large, irregular blotches, usually surrounded by a chlorotic or yellow halo; premature leaf drop can occur; more prevalent during wet weather and on trees that are under stress, particularly nutritional stress (iron deficiency).	• rake and remove fallen leaves; • prune and remove infected twigs; • maintain vigor; • fungicide sprays are usually not practical or necessary except for new transplants, young or specimen trees, or when defoliation has been heavy for several years; fungicide sprays can be applied at budbreak and repeated 2-3 times at label intervals.	chlorothalonil + thiophanate-methyl *copper hydroxide mancozeb propiconazole thiophanate-methyl

Rhododendron (Azalea, Rhododendron)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Armillaria Root Rot (*Armillaria* spp. *complex)* p. 326	Also called shoestring root rot and honey mushroom rot, this disease is difficult to identify since aboveground symptoms appear as general and progressive decline that leads to the eventual death of plants; plants can die singly or in groups; plants under environmental or site-related stresses are particularly susceptible; diagnostic signs of the infection include black strands of the fungus called rhizomorphs (shoestrings) on the surface of the bark or at the base of infected plants, white fans of fungal growth with “mushroomy” odors under the bark, and the occasional growth of honey mushrooms at the base of infected plants in autumn; the fungus can persist in stumps and large, woody roots for as long as 30 years.	• maintain vigor; • avoid any unnecessary stresses, esp. drought stress; • avoid planting susceptible trees in a site where this disease has been confirmed; • if replanting in the site, the stump and all woody roots greater than ½ inch in diameter should be removed.	No chemical control is suggested.
Botryosphaeria Canker and Dieback *(Botryosphaeria)* p. 120	Brown to black, sunken cankers develop on stems; as they girdle stems, leaves turn dull green, wilt, and branches die; some cracking of bark may occur; in cross-section, the center of the stem is dark-brown and surrounding wood a lighter brown; easily confused with *Phytophthora* dieback, although with *Botryosphaeria*, small, blister-like, black fruiting bodies are sometimes visible in the cankered areas; plants under stress are most susceptible.	• prune and remove cankered limbs 4-6 inches below visible symptoms when bark is dry; • disinfest tools between cuts; • avoid wounds or injuries; • maintain vigor; • among cultivars reported to have resistance are ‘Boursalt,’ ‘Chinodes White,’ ‘Cunningham’s White,’ and ‘English Roseum’.	No chemical control is suggested.

Rhododendron (Azalea, Rhododendron) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Botrytis Blight *(Botrytis cinerea)* p. 72	Flower clusters appear shriveled and brown; affected portions are often covered with gray, fuzzy, fungal growth; serious after periods of prolonged humidity, rain, or cloud cover; can result in some twig dieback.	• prune and remove infected twigs and blighted flower clusters; • maintain vigor; • fungicide sprays can be applied at budbreak in wet springs or when symptoms first appear; sprays can be repeated as necessary according to label directions.	chlorothalonil chlorothalonil + thiophanate-methyl copper hydroxide copper sulphate pentahydrate mancozeb mancozeb + copper hydroxide *potassium bicarbonate *sulfur thiophanate-methyl
Chlorosis *(Abiotic)* p. 490	Symptoms often develop on the newest growth, which generally appears pale-green or yellow; the veins of yellowed leaves frequently remain green; usually associated with an iron deficiency due to soil, site, or root health conditions (e.g., soil pH, root damage due to drought, excess moisture, or disease); refer to fact sheet for more detailed information.	• maintain plant vigor; • a soil test might help to determine the cause of the problem and may call for applications of chelated iron.	No chemical control is suggested.

Rhododendron (Azalea, Rhododendron) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Crown Gall *(Agrobacterium tumefaciens)* p. 382	Galls ranging in size from ¼ inch to several inches in diameter develop on branches and roots; young galls appear white or cream-colored when cut in half; older galls darken to brown and have no recognizable internal structure (e.g., no organized vascular tissue).	• prune and remove young stem galls as soon as evident; • disinfest tools between cuts; • severely infected plants should be rogued and removed; • avoid mechanical injuries to neighboring plants using careful cultivation since the bacterium requires wounds to infect; • plant resistant species (refer to list of resistant species, Table 2).	No chemical control is suggested.
Fungal Leaf Spots *(Phomopsis, Pseudocercospora, Septoria)* p. 24,138,146	Irregular or circular, brown, dead spots or patches develop over the leaves, particularly during wet weather; the size, shape, and color of these spots varies with the specific pathogen; for example, spots associated with *Pseudocercospora* are circular, have tan centers, and red or purple, highly defined margins; some yellowing of the leaves and premature leaf drop may also occur; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • provide good air circulation and avoid overhead watering; • maintain vigor; • spraying is usually not necessary since the disease has no significant impact on tree health; on specimen plants, fungicides can be applied when new growth emerges and repeated as necessary according to label directions.	chlorothalonil chlorothalonil + thiophanate-methyl *copper hydroxide mancozeb mancozeb + copper hydroxide mancozeb + thiophanate-methyl myclobutanil propiconazole thiophanate-methyl triadimefon

Rhododendron (Azalea, Rhododendron) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Gray Blight *(Pestalotiopsis)* p. 190	Symptoms usually develop on tissues that have been injured or damaged, usually from winter drying or sunscalding; infected tissues appear distinctly gray and there is often a sharp line delineating the infected from the healthy tissues; small, black, pinpoint fruiting structures of the fungus are visible in the infected tissues; heavily infected leaves can drop prematurely.	• maintain vigor; • avoid planting in open or windy sites.	No chemical control is suggested.
Leaf Gall *(Exobasidium vaccinii)* p. 250	Especially problematic on azalea; portions of or entire leaves and flowers thicken and become fleshy; these swollen areas or galls are pale-green but can develop a rosy color; as galls age, they turn white due to the formation of spores of the fungus on the surface; galls eventually turn brown and dry out; refer to fact sheet for more detailed information.	• pick and remove as many galls as possible before they turn white; • maintain vigor; • fungicides are registered for use but are usually not necessary; sprays can be applied when new growth emerges and repeated as necessary according to label directions.	*basic copper sulfate chlorothalonil + thiophanate-methyl mancozeb mancozeb + copper hydroxide triadimefon

Rhododendron (Azalea, Rhododendron) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Phytophthora Root Rot *(Phytophthora* spp.*)* p. 354	Infected plants generally exhibit poor vigor; leaves roll longitudinally along midveins, appear dull, olive-green, and wilted but usually remain attached to branches; branches and twigs shrivel; symptoms may be confined to individual branches or may develop progressively until the entire plant is involved; a distinctive cinnamon-brown discoloration may be evident when cuts are made into the wood at the root crown; frequently more serious on shrubs where excess water is a persistent problem (e.g., clay soils, low areas); definitive diagnosis usually requires laboratory tests; refer to fact sheet for more detailed information.	• once infected, plants cannot be cured; • rogue and remove symptomatic plants; • avoid planting in poorly drained soils or improve drainage; • maintain vigor and avoid excessive irrigation; • some resistance has been identified (e.g., 'Caroline,' 'Professor Hugo de Vries,' 'Red Head'); • fungicides are not curative; healthy, uninfected plants adjacent to symptomatic plants can be protected with fungicides applied according to label directions.	fosetyl-Al mefenoxam mono- and di- potassium salts of phosphorus acid phosphorous acid
Phytophthora Tip Dieback/Shoot Blight *(Phytophthora* spp.*)* p. 354	Leaves and terminal buds begin to discolor; leaves turn brown and droop; a diagnostic V-shaped, water-soaked discoloration may be evident on the leaves, usually beginning at the point of petiole attachment to the leaf lamina; browning of the petiole often continues as the fungus-like organism moves into the twig; girdling cankers may form on twigs and branches and result in dieback; current season's growth is most susceptible.	• prune and remove affected tips below obvious symptoms; • disinfest tools between cuts; • avoid excessive vigor; • fungicide sprays can be applied according to label directions when new shoots are growing; they are effective as protectants and have no curative action.	azoxystrobin chlorothalonil chlorothalonil + iprodione chlorothalonil + thiophanate-methyl *copper hydroxide mancozeb mancozeb + copper hydroxide mefenoxam

Rhododendron (Azalea, Rhododendron) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Powdery Mildew *(Erysiphe)* p. 8	Symptoms vary considerably with species and cultivar; on some cultivars, white to grayish, powdery growth typical of other powdery mildews is evident on leaves; this is usually first evident on upper leaf surfaces but can occur on both surfaces of leaves; in other cases, symptoms are atypical and include pale-yellow spots with diffuse margins, purple to brown, circular patches, purplish-brown discolorations of veins, and necrotic blotches; symptoms usually develop fairly late in the season; some yellowing and premature leaf drop may occur; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • avoid excessive fertilization since tender, succulent leaves are more susceptible; • provide good air circulation around the tree; • spraying is usually not necessary since the disease has no significant impact on tree health; on specimen trees, fungicides can be applied as soon as symptoms are evident and repeated as necessary.	azoxystrobin chlorothalonil + thiophanate-methyl mancozeb + copper hydroxide mancozeb + thiophanate-methyl myclobutanil *potassium bicarbonate propiconazole *sulfur thiophanate-methyl triadimefon
Winter Injury *(Abiotic)* p. 498	Browning of leaf tips or margins, rolling of leaves; dieback and shriveling of branches and twigs can be extensive; symptoms most evident in late winter or early spring as growth resumes; sub-lethal damage to the cambium may also occur and symptoms associated with this damage appear in early summer as a sudden, "unexplained" collapse of branches or entire plants; refer to fact sheet for more detailed information.	• prune and remove symptomatic tissues to minimize secondary invaders and opportunistic pests; • maintain vigor; • provide adequate moisture in the root zone before the ground freezes; • provide physical (e.g., burlap wraps) and/or chemical (e.g., applications of anti-transpirants) protection in wind-swept areas or in areas prone to extreme temperature fluctuations during the winter.	No chemical control is suggested.

Robinia (Black Locust)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Canker *(Nectria* spp.) p. 176	Symptoms include progressive dieback of twigs and branches, usually first evident on lower limbs and proceeding up the tree; cankers appear as sunken areas of bark on branches or the main trunk; brightly colored orange or reddish-orange fruiting structures of the fungus are sometimes visible in the cankers.	• prune and remove symptomatic twigs and branches as soon as evident; • cuts should be made below visible symptoms when bark is dry; • maintain vigor since drought-stressed or winter-injured trees are more vulnerable; • avoid mechanical injuries; • maintain vigor.	No chemical control is suggested.
Powdery Mildew *(Erysiphe)* p. 8	White to grayish, powdery growth on leaves, usually first evident on upper leaf surfaces but can occur on both surfaces of leaves; develops fairly late in the season; some premature fall coloration and leaf drop may occur; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • avoid excessive fertilization since tender, succulent leaves are more susceptible; • provide good air circulation around the tree; • spraying is usually not necessary since the disease has no significant impact on tree health; on specimen trees, fungicides can be applied as soon as symptoms are evident and repeated as necessary.	chlorothalonil + thiophanate-methyl myclobutanil thiophanate-methyl triadimefon

Rosa (Rose)

Disease *(Pathogen/Cause)*	Diagnostic Symptoms	Management	Materials
Black Spot *(Diplocarpon rosae)* p. 80	Brown to black lesions with feathery, indistinct margins develop on leaves; spots can be up to ½ inch in diameter and can develop on both leaf surfaces; on highly susceptible cultivars, both symptomatic and non-symptomatic leaves turn yellow and drop prematurely, often in significant numbers; canes may develop purple spots and cankers on current growth; this disease can be severe during cool, wet weather; refer to fact sheet for more detailed information.	• prune and remove cankered and dead canes; • rake and remove fallen leaves; • avoid overhead irrigation and provide spacing for good air circulation; • maintain vigor; • resistance is available (e.g., highly resistant hybrid teas- ‘Tropicana,’ ‘Mr. Lincoln,’ ‘David Thompson,’ ‘Coronado,’ ‘Peace’); however, strains of the fungus may influence individual disease reactions; • fungicide sprays can be applied as soon as new growth begins in spring and repeated as necessary according to label directions; sprays are often necessary throughout the entire growing season for control on highly susceptible cultivars.	chlorothalonil chlorothalonil + iprodione chlorothalonil + thiophanate-methyl *copper hydroxide copper sulphate pentahydrate mancozeb mancozeb + copper hydroxide mancozeb + thiophanate-methyl myclobutanil propiconazole *sulfur thiophanate-methyl trifloxystrobin

Rosa (Rose) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Botrytis Blight *(Botrytis cinerea)* p. 120	Symptoms appear on flowers, buds, canes, and growing tips after periods of cloudy, humid weather; on flowers and flower buds, small flecks or blister-like patches that develop into tan spots or large, tan patches appear on petals; stem cankers develop at pruning wounds or injuries and succulent growing tips wilt and die from girdling cankers; under conditions of high humidity and moisture, infected tissues are covered with the tan, fuzzy mass of the fungus; refer to fact sheet for more detailed information.	• prune and remove infected tips and canes; • avoid overhead irrigation and provide adequate spacing for air circulation; • remove spent flowers; • avoid unnecessary injuries; • maintain vigor; • fungicide sprays can be applied as soon as symptoms first appear and repeated as necessary.	chlorothalonil chlorothalonil + iprodione chlorothalonil + thiophanate-methyl copper sulphate pentahydrate mancozeb mancozeb + copper hydroxide mancozeb + thiophanate-methyl *potassium bicarbonate thiophanate-methyl
Cankers *(Nectria, Phomopsis)* p. 176, 140	Slightly sunken, reddish-brown spots develop on canes; these lesions gradually enlarge, girdle, and kill the canes; affected tissues may turn tan to light-brown and, depending on the species of fungus, black fruiting bodies may be evident in longitudinal splits or evenly distributed throughout the cankered areas; refer to fact sheet for more detailed information.	• prune and remove infected canes below visible symptoms; • disinfest tools between cuts; • maintain vigor.	No chemical control is suggested.

Rosa (Rose) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Crown Gall *(Agrobacterium tumefaciens)* p. 382	Galls ranging in size from ¼ inch to several inches in diameter develop on branches and roots; young galls appear white or cream-colored when cut in half; older galls darken to brown and have no recognizable internal structure (e.g., no organized vascular tissue); refer to fact sheet for more detailed information.	• prune and remove young stem galls as soon as evident; • disinfest tools between cuts; • severely infected plants should be rogued and removed; • avoid mechanical injuries to neighboring plants using careful cultivation since the bacterium requires wounds to infect; • plant resistant species (refer to list of resistant species, Table 2).	No chemical control is suggested.
Dieback *(Botryosphaeria)* p. 120	Brown to black, sunken cankers develop on canes; as they girdle stems, leaves turn dull green and wilt, and branches die; some cracking of bark may occur; in cross-section, the center of the stem is dark-brown and the surrounding wood a lighter brown; small, blister-like, black fruiting bodies are sometimes visible in the cankered areas; plants under stress are most susceptible.	• prune and remove cankered limbs 4-6 inches below visible symptoms when bark is dry; • disinfest tools between cuts; • avoid wounds or injuries; • maintain vigor.	No chemical control is suggested.

Rosa (Rose) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Downy Mildew *(Peronospora sparsa)* p. 352	Symptoms can develop on all plant parts including leaves, stems, peduncles, calyxes, and petals; leaves develop purplish to dark-brown spots that are irregular in appearance; these spots are usually most obvious on the upper leaf surface but can be confused with phytotoxicity; extensive yellowing and leaf drop can occur when infection is heavy; under humid conditions, the fungus may be visible as fuzzy, purplish-brown growth on the undersurfaces of symptomatic leaves; purplish, sunken cankers can develop on canes; this disease is most serious during cool, wet weather; refer to fact sheet for more detailed information.	• prune and remove canes several inches below visible cankers; • rake and remove fallen leaves; • maintain vigor; • fungicide sprays can be applied on a preventative basis as soon as new growth emerges and repeated as necessary according to label directions.	copper hydroxide copper sulphate pentahydrate fosetyl-Al mancozeb

Rosa (Rose) cont'd

Disease *(Pathogen/Cause)*	Diagnostic Symptoms	Management	Materials
Powdery Mildew *(Podosphaera)* p. 8	Whitish-gray, powdery growth appears on leaves, young canes, and flower parts; symptoms usually don't appear until early to midsummer; if infections occur early in the season, tender canes may be killed by heavy infections; when young leaves are infected, some twisting and distortion may occur; heavily infected flower buds may fail to open and premature leaf drop may occur; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • provide good air circulation; • resistance is available (e.g., hybrid teas 'Tropicana,' 'Mr. Lincoln,' 'Sonia,' 'Fragrant Cloud'); • highly susceptible cultivars can be sprayed with fungicides as soon as symptoms are evident and repeated as necessary.	azoxystrobin chlorothalonil chlorothalonil + iprodione chlorothalonil + thiophanate-methyl *copper hydroxide copper sulphate pentahydrate *horticultural oil mancozeb + copper hydroxide mancozeb + thiophanate-methyl myclobutanil *potassium bicarbonate propiconazole *sulfur thiophanate-methyl triadimefon

Rosa (Rose) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Rose Mosaic *(Virus complex)* p. 408	Symptoms are highly variable and include ringspots, chlorotic line patterns, mottles, and mosaics on leaves; symptoms also vary with cultivar, weather, and time of year; there is no obvious effect on flowering but infected plants often have reduced vigor and are prone to winter injury; refer to fact sheet for more detailed information.	• maintain vigor; • remove heavily infected plants.	No chemical control is suggested.
Rose Rosette *(Rose Rosette Virus)** Vector: eriophyid mite, *Phyllocoptes fructiphilus* p.418 *still somewhat inconclusive	Hosts include most *Rosa* species and cultivars; multiflora rose is highly susceptible and the primary source of the virus; symptoms include witches'-brooms, reddish coloration of leaves and stems, thickened stems, deformed leaves and flowers, and excessive thorniness; symptoms easily confused with herbicide damage; spread by grafting and by eriophyid mites (which can also be blown around in the wind); transmission typically occurs in May-mid-July; symptoms from new infections usually start appearing in mid-July; the virus becomes systemic in the plant and infected plant susually die in 1 to 5 years; characteristic symptoms have been obseved in CT since 2009, however the first definitive molecular confirmation was completed in 2014; laboratory testing is required for definitive identification.	• remove multiflora rose in the vicinity of plantings; • remove ornamental roses with symptoms,, including the rootstock; • prune dormants roses in spring to reduce overwintering mite populations; • clean and disinfest ppruning tools; • if new infections are observed, cut back symptomatic shoots to the ground and monitor regrowth for symptoms; • manage mite populations with appropriate miticides (season-long control is most effective but isn't always practical or successful).	No chemical control is suggested.

Rosa (Rose) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Rose Rust *(Phragmidium* spp.*)* p. 258	Symptoms can develop on leaves and any other green parts of the plant; small, orange pustules develop on both leaf surfaces in early spring; they gradually enlarge and by late summer or early fall they turn black and contain the spores for winter survival; heavy infections result in early defoliation.	• rake and remove infected leaves; • prune "rusted" canes back to healthy wood in spring prior to budbreak; • provide adequate spacing between plants to allow good air circulation; • avoid overhead irrigation; • maintain vigor; • highly susceptible cultivars can be sprayed with fungicides when new growth begins in spring or as soon as symptoms are evident and repeated as necessary.	azoxystrobin chlorothalonil + thiophanate-methyl mancozeb mancozeb + copper hydroxide myclobutanil propiconazole trifloxystrobin
Winter Injury *(Abiotic)* p. 498	Symptoms include dieback of canes and death of entire plants; dieback can be extensive after some winters; symptoms are most evident in early spring as growth resumes; sub-lethal damage to the cambium may also occur and symptoms appear in early summer as a shriveling of newly developing shoots or as a sudden, "unexplained" collapse of canes; refer to fact sheet for more detailed information.	• prune and remove dead canes to minimize secondary invaders and opportunistic pests; • maintain vigor; • provide physical protection to the graft union in areas prone to extreme temperature fluctuations during the winter.	No chemical control is suggested.

Salix (Willow)

Disease *(Pathogen/Cause)*	Diagnostic Symptoms	Management	Materials
Canker *(Botryosphaeria, Cytospora)* p. 120, 172	Twigs and branch tips wilt and die back; may be first confined to individual limbs but can encompass the entire tree; leaves usually droop and turn brown yet remain attached to the stem; discolored, brown cankers appear as flattened areas on killed stems or branches.	• prune and remove symptomatic twigs or branches back to healthy wood when bark is dry; • avoid wounds and drought stress since the fungus is more aggressive on plants that have been weakened by drought or winter injuries.	No chemical control is suggested.
Leaf Rust *(Melampsora* spp.*)* p. 284	Several species of fungi cause rust symptoms on willow; small, bright lemon-yellow spots appear on upper leaf surfaces, and orange pustules or blisters develop on upper leaf surfaces in late spring or summer; the lesions gradually darken in color; heavy infections result in premature leaf drop; these fungi overwinter on fallen willow leaves or, in some cases, in buds and twigs of infected trees; alternate hosts of these fungi include balsam fir and larch; in spring, spores develop on fallen willow leaves and infect emerging conifer needles; yellow pustules develop on these needles and spores produced on these infected needles infect willow leaves.	• rake and remove fallen leaves; • provide good air circulation around the tree; • spraying is usually not necessary since the disease has no significant impact on tree health; on specimen trees, fungicides can be applied as new growth emerges in spring and repeated as necessary according to label directions.	mancozeb

Salix (Willow) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Powdery Mildew *(Erysiphe)* p. 8	Whitish-gray, powdery or felt-like growth appears on leaves; symptoms usually don't appear until early to midsummer; premature leaf drop may occur; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • provide good air circulation; • highly susceptible cultivars can be sprayed with fungicides as soon as symptoms are evident and repeated as necessary.	chlorothalonil + thiophanate-methyl *horticultural oil mancozeb + copper hydroxide mancozeb + thiophanate-methyl myclobutanil *potassium bicarbonate triadimefon

Salix (Willow) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Willow Blight (Complex of Black Canker, *Glomerella miyabeana* **and Scab**, *Venturia saliciperda)* p. 92	Symptoms of both diseases are very similar and most landscape trees are infected by both pathogens; Symptoms of **scab** include a rapid blighting of leaves and shoots; young leaves are killed as they emerge from the buds and the pathogen moves into the small twigs through the petioles; symptoms of **black canker** are similar but usually don't develop until later in the season; brown to black spots first appear on leaves in midsummer; a rapid blighting of leaves and shoots occurs and blackened lesions or cankers develop as the fungus readily moves from the petiole of infected leaves into the twig where girdling cankers are formed; cankers appear as discolored depressions in the bark and cause splitting; these cankers develop on larger-diameter wood than those associated with scab; **blight** kills highly susceptible trees by repeated defoliation and destruction of shoots; most species have some degree of susceptibility since both fungi are considered to be aggressive pathogens; willow blight is favored by wet weather.	• prune and remove infected twigs or branches; • some resistance has been reported (*S. babylonia*, *S. pentandra*); • maintain vigor.	No chemical control is suggested.

Sassafras (Sassafras)

Disease *(Pathogen/Cause)*	Diagnostic Symptoms	Management	Materials
Anthracnose *(Colletotrichum)* p. 114	Irregular, brown to reddish-brown (often papery) areas develop along and sometimes between veins and at leaf margins; symptoms are very similar to those associated with drought and heat stress; some defoliation may occur when infection is heavy; occasional tip dieback; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • prune dead twigs and branches; • chemical control is usually not necessary except for new transplants, young or specimen trees, or when defoliation has been heavy for several years; fungicide sprays can be applied at budbreak and repeated 2-3 times at label intervals.	chlorothalonil mancozeb thiophanate-methyl
Armillaria Root Rot *(Armillaria* spp. *complex)* p. 326	Also called shoestring root rot and honey mushroom rot; this disease is difficult to identify since aboveground symptoms appear as general and progressive decline that leads to the eventual death of trees; trees can die singly or in groups; trees under environmental or site-related stresses are particularly susceptible; diagnostic signs of the infection include black strands of the fungus called rhizomorphs (shoestrings) on the surface of the bark or at the base of infected trees, white fans of fungal growth with “mushroomy” odors under the bark, and the occasional growth of honey mushrooms at the base of infected trees in autumn; narrow, black lines are often evident in infected wood; the fungus can persist in stumps and large, woody roots for as long as 30 years.	• maintain tree vigor; • avoid any unnecessary stresses, esp. drought stress; • avoid planting susceptible trees in a site where this disease has been confirmed; • if replanting in the site, the stump and all woody roots greater than ½ inch in diameter should be removed.	No chemical control is suggested.

Sassafras (Sassafras) cont'd

Disease *(Pathogen/Cause)*	Diagnostic Symptoms	Management	Materials
Canker *(Botryosphaeria, Nectria)* p. 120, 176	Symptoms include progressive dieback of twigs and branches, usually first evident on lower limbs and proceeding up the tree; cankers appear as sunken areas of bark on branches or the main trunk.	• prune and remove symptomatic twigs and branches as soon as evident; • cuts should be made below visible symptoms when bark is dry; • maintain vigor since drought-stressed or winter-injured trees are more vulnerable; • avoid mechanical injuries; • maintain vigor.	No chemical control is suggested.
Powdery Mildew *(Erysiphe)* p. 8	Whitish-gray, powdery or felt-like growth appears on leaves; symptoms usually don't appear until early to midsummer; premature leaf drop may occur; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • provide good air circulation; • highly susceptible cultivars can be sprayed with fungicides as soon as symptoms are evident and repeated as necessary.	*horticultural oil mancozeb + copper hydroxide mancozeb + thiophanate-methyl myclobutanil *potassium bicarbonate thiophanate-methyl triadimefon

Sassafras (Sassafras) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Verticillium Wilt *(Verticillium* spp.*)* p. 242	Flagging or wilting of individual limbs or portions of the canopy, usually in midsummer; leaves can be undersized and infected trees sometimes have heavy seed set; trees die slowly or suddenly, depending on the extent of infection and overall health of the tree; a distinctive olive-brown streaking may be evident in the wood of symptomatic branches or twigs; laboratory examination and culturing are usually required for definitive identification; refer to fact sheet for more detailed information.	• prune and remove affected limbs as soon as symptoms are evident; • disinfest tools between cuts; • promote tree vigor; • avoid drought stress; • do not replant susceptible species in the area since the fungus is soilborne (refer to list of resistant species, Table 1).	No chemical control is suggested.

Sophora (Japanese Pagoda-tree, Pagoda-tree)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Canker and Twig Blight *(Fusarium lateritium)* p. 186	Cankers result in twig dieback and subsequent thinning of the canopy; cankers are annual and often initiated at wounds; they are elliptical and tan, with purplish-brown margins that are readily distinguished from healthy tissues; cankers are often associated with freeze damage; peach-colored fruiting structures are often found erupting from lenticels within the cankers.	• prune affected limbs back to healthy wood as soon as detected and when bark is dry; • avoid wounding; • maintain tree vigor.	No chemical control is suggested.
Twig Blight *(Nectria cinnabarina)* p. 176	Random dieback of branches and limbs; usually associated with sunken cankers that are often covered with distinctive coral-colored or orange fruiting structures of the fungus; problematic on trees weakened by other factors such as drought.	• prune affected limbs as soon as detected when bark is dry; • avoid wounding; • maintain tree vigor.	No chemical control is suggested.
Verticillium Wilt *(Verticillium* spp.*)* p. 242	Flagging or wilting of individual limbs or portions of the canopy, usually in midsummer; leaves can be undersized and infected trees sometimes have heavy seed set; trees die slowly or suddenly, depending on the extent of infection and overall health of the tree; a distinctive olive-brown streaking may be evident in the wood of symptomatic branches or twigs; laboratory examination and culturing are usually required for definitive identification; refer to fact sheet for more detailed information.	• prune and remove affected limbs as soon as symptoms are evident; • disinfest tools between cuts; • promote tree vigor; • avoid drought stress; • do not replant susceptible species in the area since the fungus is soilborne (refer to list of resistant species, Table 1).	No chemical control is suggested.

Sorbus (Mountain Ash)

Disease *(Pathogen/Cause)*	Diagnostic Symptoms	Management	Materials
Cankers *(Cytospora, Fusicoccum)* p. 172	Progressive wilting and dieback of branches; sunken or swollen, discolored areas develop on twigs, branches, and limbs; as these cankers enlarge, they encircle and girdle the affected plant part and result in death of these tissues; small fruiting structures of the fungus can develop in the cankered areas; symptoms are more pronounced on trees weakened by environmental or site-related stresses.	• prune and remove symptomatic twigs and branches when bark is dry; • maintain vigor; • avoid wounding or unnecessary stresses.	No chemical control is suggested.
Fire Blight *(Erwinia amylovora)* p. 376	Flowers wither and blacken; young twigs and branches die from the terminals back and appear as though "burned"; affected limbs frequently develop a characteristic shepherd's crook at the tips; dead leaves usually remain attached to the branch; sunken, discolored cankers may be evident on branches or the main trunk; symptoms often develop in a relatively short period of time; refer to fact sheet for more detailed information.	• avoid excessive nitrogen fertilization or vigor; • overwintering cankers should be pruned and removed during the winter; make cuts at least 10-12 inches below visible symptoms when bark is dry; • during the growing season, prune and remove infected branches as soon as they develop; make cuts at least 10-12 inches below visible symptoms when bark is dry; • carefully remove prunings to avoid spread; • disinfest tools between cuts; • preventative copper sprays can be applied to the bark before growth emerges in spring; additional applications may be necessary to protect newly emerging shoots until flowering.	*copper hydroxide copper sulphate pentahydrate mancozeb + copper hydroxide

Sorbus (Mountain Ash) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Leaf Blotch *(Colletotricum)* p. 114	Symptoms include blossom blight, leaf spots, leaf and shoot blights, cankers, dieback of twigs and branches, and tree death; large, irregular, necrotic areas develop on leaves and result in early defoliation; trees weakened by environmental and site-related stresses are more susceptible.	• rake and remove fallen leaves; • prune any infected twigs and branches when bark is dry; • provide good air circulation; • maintain tree vigor; • spraying is usually not necessary since the disease has no significant impact on tree health; on specimen trees, fungicides can be applied when new growth begins and repeated as necessary according to label directions.	mancozeb mancozeb + copper hydroxide thiophanate-methyl
Leaf Spot *(Diplocarpon mespili)* p. 78	Discrete, circular, dark-brown spots develop on leaves; when numerous, they coalesce and form large, dead blotches; fruiting structures of the fungus develop under the cuticle of lesions and give the spots a blister-like appearance; significant early leaf drop can occur.	• rake and remove fallen leaves; • provide good air circulation; • maintain tree vigor; • spraying is usually not necessary since the disease has no significant impact on tree health; on specimen trees, fungicides can be applied as new growth emerges in spring and repeated as necessary according to label directions.	mancozeb mancozeb + copper hydroxide mancozeb + thiophanate-methyl thiophanate-methyl

Sorbus (Mountain Ash) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Rusts *(Gymnosporangium* spp.*)* p. 262	Since several rust species attack this host, symptoms can vary; the most common rusts in the landscape are cedar-hawthorn (*G. globosum*) and quince (*G. clavipes*); distinctive yellowish-orange spots first appear on upper leaf surfaces in late May or June; as the fungus develops in the leaf, spots become noticeable on the undersurfaces; on close examination and depending on which species of fungus is responsible, rings of small, cup-like structures or long, tendrils of the fungus are visible; heavily infected leaves become chlorotic and often drop prematurely by mid-July; these rust fungi require other hosts (*Juniperus* spp.) in order to complete their life cycles; refer to fact sheet for more detailed information.	• for specimen trees, eliminate the alternate hosts (any red cedar or juniper species) within a one-mile radius, if possible; • resistant species are available (e.g., *M. baccata* 'Ellwangerina'; *M. floribunda* 'Henry Kohankie,' 'Ormiston Roy,' 'Red Baron'); a more extensive list is available upon request; • fungicide sprays can be applied when new growth is emerging in spring; this is usually when the gelatinous, orange telial horns are visible on the junipers (usually mid-May); sprays are repeated as necessary at label intervals; • select the appropriate fungicide if harvesting fruit for consumption.	azoxystrobin chlorothalonil chlorothalonil + iprodione chlorothalonil + thiophanate-methyl fenarimol mancozeb mancozeb + thiophanate-methyl myclobutanil propiconazole *sulfur thiophanate-methyl triadimefon trifloxystrobin
Scab *(Venturia inaequalis)* p. 86	Circular, olive-black, velvety spots with feathery, diffuse margins develop on leaves, fruit, and young fruit stems; heavy infections result in leaf yellowing and significant defoliation in midsummer; infected fruit often crack and occasionally drop.	• rake and remove fallen leaves; • maintain tree vigor since repeated defoliation weakens trees; • chemical control is usually not necessary except for new transplants, young or specimen trees, or when defoliation has been heavy for several years; fungicide sprays can be applied at budbreak and repeated 2-4 times at label intervals; early-season sprays are very important.	copper sulphate pentahydrate mancozeb mancozeb + copper hydroxide thiophanate-methyl

Spirea (Spirea)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Fire Blight *(Erwinia amylovora)* p. 376	While only an occasional problem, when infection does occur, disease can develop quite rapidly and destroy individual trees in a single season; flowers appear water-soaked, burned, and then shrivel but usually remain attached throughout the season; when new shoots are infected, they develop a distinctive "shepherd's crook" and appear scorched or burned; blackened leaves cling to the branch and don't fall off; cankers, identified as sunken, discolored areas on branches or the main trunk, may appear wet and oozing during wet weather in spring; refer to fact sheet for more detailed information.	• prune and remove infected branches at least 10-12 inches below visible symptoms when bark is dry; • disinfest tools between cuts; • avoid excessive nitrogen fertilization or vigor.	No chemical control is suggested.
Powdery Mildew *(Podosphaera)* p. 8	White to grayish, powdery growth on leaves, usually first evident on upper leaf surfaces but can occur on both surfaces of leaves; develops fairly late in the season; some premature fall coloration and leaf drop may occur; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • avoid excessive fertilization since tender, succulent leaves are more susceptible; • provide good air circulation around the tree; • spraying is usually not necessary since the disease has no significant impact on tree health; on specimen trees, fungicides can be applied as soon as symptoms are evident and repeated as necessary.	azoxystrobin chlorothalonil chlorothalonil + thiophanate-methyl *horticultural oil mancozeb myclobutanil thiophanate-methyl triadimefon

Syringa (Lilac)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Ascochyta Blight *(Ascochyta syringae)* p. 38	Initial symptoms develop in spring as newly emerging shoots appear blighted and shrivel, droop, and turn brown; foliar symptoms also develop in late summer and early autumn and appear as olive-green, water-soaked lesions; these vary from discrete spots to large, irregular lesions; can be confused with bacterial and Phytophthora blights; especially problematic during wet weather.	• rake and remove fallen leaves; • prune and remove blighted shoots and cankered limbs; • fungicide sprays have questionable results but can be applied when new shoots emerge in spring and repeated as necessary according to label directions.	chlorothalonil chlorothalonil + thiophanate-methyl thiophanate-methyl
Bacterial Blight *(Pseudomonas syringae* pv. *syringae)* p. 368	Leaves, shoots, and sometimes flower clusters shrivel and die; first symptoms are irregular to circular, black, water-soaked spots with occasional yellow halos; spots coalesce and leaves develop a blighted appearance; petioles and tender stems become infected, turn brown to black, and droop; elongate, black cankers often develop on current-season wood; blighted tissues usually persist on the tree; symptoms are very similar to frost injury and Phytophthora blight; often requires microscopic examination for identification.	• prune symptomatic leaves and shoots well below obvious symptoms as soon as possible; • disinfest tools between cuts; • maintain vigor but avoid excessive fertilization; • provide adequate spacing between plants for good air circulation; • protectant sprays can be applied as new growth emerges in spring and repeated as necessary according to label directions.	copper sulfate copper sulphate pentahydrate mancozeb + copper hydroxide
Phytophthora Blight *(Phytophthora cactorum)* p. 354	Dark-brown, irregular lesions develop on leaves, shoots, and flower clusters; dark - brown lesions appear on petioles and new shoots resulting in a collapsed or blighted appearance; symptoms are very similar to bacterial blight; often requires microscopic examination for identification.	• prune symptomatic leaves and shoots well below obvious symptoms as soon as possible; • disinfest tools between cuts; • avoid overhead irrigation; • maintain vigor but avoid excessive fertilization.	No chemical control is suggested.

Syringa (Lilac) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Powdery Mildew *(Erysiphe)* p. 8	Very heavy, white to grayish, powdery growth on leaves, usually most visible on the upper surfaces of leaves; develops fairly late in the season; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • spraying is usually not necessary since the disease has no significant impact on plant health; on specimen plants, fungicides can be applied as soon as symptoms are evident and repeated as necessary.	azoxystrobin chlorothalonil chlorothalonil + thiophanate-methyl *horticultural oil mancozeb + thiophanate-methyl myclobutanil *potassium bicarbonate propiconazole *sulfur thiophanate-methyl triadimefon
Witches' Broom *('Candidatus* Phytoplasma fraxini*')* p. 390	Numerous, slender shoots forming witches' brooms proliferate from random locations on branches; leaves on these shoots are usually chlorotic and undersized; brooms are frequently not winter-hardy; entire plants can die within a few years of forming witches'-brooms; late-flowering species seem to be particularly susceptible; caused by the same phytoplasma responsible for Ash Yellows.	• prune and remove symptomatic limbs or entire plants; • maintain vigor; • avoid plant late-flowering species where this disease is prevalent; • insect vectors such as leafhoppers are involved in disease transmission but have not yet been identified.	No chemical control is suggested.

Taxus (Yew)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Armillaria Root Rot *(Armillaria* spp. *complex)* p. 326	Also called shoestring root rot and honey mushroom rot; this disease is difficult to identify since aboveground symptoms appear as general and progressive decline that leads to the eventual death of trees; trees can die singly or in groups; trees under environmental or site-related stresses are particularly susceptible; on conifers, excessive resin production at points of infections or at the bases of trees can be important symptoms of infection; the diagnostic black strands of the fungus called rhizomorphs (shoestrings) are usually not present on conifers; signs of the infection includes white fans of fungal growth with “mushroomy” odors under the bark and the occasional growth of honey mushrooms at the base of infected trees in autumn; the fungus can persist in stumps and large, woody roots for as long as 30 years.	• maintain vigor; • avoid any unnecessary stresses, esp. drought stress; • avoid planting susceptible trees in a site where this disease has been confirmed; • if replanting in the site, the stump and all woody roots greater than ½ inch in diameter should be removed	No chemical control is suggested.
Botryosphaeria Canker *(Botryosphaeria)* p. 120	Random dieback of branches and limbs; usually associated with sunken cankers in which black fruiting structures of the fungus may be visible; problematic on trees weakened by other factors such as drought.	• prune affected limbs back to healthy wood as soon as detected and when bark is dry; • avoid wounding and unnecessary stress such as drought stress; • maintain tree vigor.	No chemical control is suggested.

Taxus (Yew) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Dieback *(Abiotic)* p. 502	Symptoms include unexplained dieback and collapse of new and established plants; early symptoms appear as yellowing of growing tips followed by general yellowing, wilting, collapse, and death of the entire plant; a "wet" decay or rot is often evident at the root/crown area; usually associated with unfavorable soil conditions that include acidic soil pH (4.0-5.4) and heavy, poorly-drained soils.	• maintain vigor; • pay attention to planting site and soil conditions since *Taxus* is particularly susceptible to soil.	No chemical control is suggested.
Oedema *(Abiotic)* p. 502	Symptoms first appear as raised, water-soaked blisters on the undersides of needles; blisters eventually become corky and tan to rusty-brown; often misidentified as insects (e.g., scale); frequently associated with heavy, wet soils;	• maintain vigor; • avoid planting in wet or poorly-drained sites.	No chemical control is suggested.
Phytophthora Root and Stem Rot *(Phytophthora* spp.*)* p. 354	Infected plants generally exhibit poor vigor; needles initially appear dull, olive-green but then turn reddish brown; they usually remain attached to branches; branches and twigs shrivel; symptoms may be confined to individual branches or may develop progressively until the entire plant is involved; a diagnostic cinnamon-brown discoloration may be evident when cuts are made into the wood at the root/crown area; frequently more serious on shrubs where excess water is a persistent problem (e.g., clay soils, low areas).	• plants cannot be cured once they are infected; • rogue and remove symptomatic plants; • avoid excessive irrigation and improve drainage; • maintain vigor; • healthy, uninfected plants adjacent to symptomatic plants can be protected with fungicide applications applied according to label directions.	fosetyl-Al mefenoxam

Thuja (Arborvitae)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
"Black" Disease *(Unknown)*	Needles develop a distinctly shiny black appearance; symptoms can be randomly distributed throughout the plant and do not appear to be associated with site, age, or cultivar; possible suggestions for causes include nutrient deficiencies or toxicities and air pollutants.	• maintain vigor.	No chemical control is suggested.
Botryosphaeria Canker *(Botryosphaeria)* p. 120	Random dieback of branches and limbs; usually associated with sunken cankers in which black fruiting structures of the fungus may be visible; problematic on trees weakened by other factors such as drought.	• prune affected limbs back to healthy wood as soon as detected and when bark is dry; • avoid wounding and unnecessary stress such as drought stress; • maintain tree vigor.	No chemical control is suggested.
Botrytis Blight *(Botrytis cinerea)* p. 72	Affected tissues initially appear water-soaked and then turn brown; infections are identified by the gray, fuzzy, cottony growth of the fungus on the surface of needles and shoots; the fungus moves from the needles to the shoots and into the stems causing a twig blight; with the exception of weak trees, infections usually do not extend beyond the tips or current season's growth and are often confined to tissues that have been damaged by frost; most symptomatic tissues drop off during the season.	• prune and remove symptomatic twigs; • maintain vigor; • attention to planting site to avoid potential frost pockets.	No chemical control is suggested.

Thuja (Arborvitae) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Cercospora Blight (*Cercospora* spp.) p. 32	Oriental arborvitae are very susceptible; symptoms first appear on low branches close to the main stem and progress outward and upward; affected foliage turns bronze to brown; cankers can girdle young stems and deform older ones; small, black fuzzy fruting bodies of the fungus can be seen on affected tissues with a hand lens; symptomatic foliage and dead twigs fall off; highly susceptible trees can be killed in several years.	• prune and remove symptomatic twigs; • maintain vigor; • avoid wounding and unnecessary stress such as drought stress; • provide adequate spacing between plants for good air circulation; • fungicides can be applied as new growth emerges in spring and repeated as necessary.	chlorothalonil mancozeb mancozeb + copper hydroxide thiophanate-methyl
Diplodia Blight [Sphaeropsis Tip Blight] *(Diplodia pinea)* p. 130	Tip blight results from infection of buds and shoots; infected buds and shoots usually stop growing before or during needle elongation and needles are frequently short; infected tissues are straw-colored; usually kills only current-season buds and shoots, but can cause significant dieback on trees under stress, especially under drought stress; black fruiting structures of the fungus may be visible on infected shoots; symptoms may be distributed uniformly throughout the canopy or concentrated in lower branches; refer to fact sheet for more detailed information.	• prune and remove blighted twigs and branches during dry weather in autumn; • maintain tree vigor with special attention to watering during periods of drought; • fungicide sprays can be applied at budbreak and repeated as necessary at label intervals until needles are fully expanded.	copper sulphate pentahydrate mancozeb *potassium bicarbonate propiconazole thiophanate-methyl

Thuja (Arborvitae) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Seasonal Needle Browning and Shedding *(Abiotic)* p. 520	"Symptoms" develop as the older, inner branches turn brown and drop in the fall; this is a perfectly normal phenomenon similar to deciduous trees dropping leaves in the fall; however, when the previous growing season is stressful (due to drought or excess water), shedding can be more synchronous and more dramatic and heavier than usual.	• maintain vigor.	No chemical control is suggested.
Tip Blight *(Abiotic)*	Tips and whole sections of branches progressively turn brown and die; affected needles usually remain attached to the branches; symptoms are frequently distributed uniformly on the shrub and are most obvious in spring; since secondary fungi occasionally infect these dead tissues, microscopic examination is necessary to rule out fungal tip blights (see above).	• prune and remove as much of the affected portions of the shrub as practical; this helps to reduce problems associated with secondary invaders and opportunistic pests; • maintain vigor.	No chemical control is suggested.
Twig Blights *(Kabatina, Pestalotiopsis, Phomopsis)* p. 146, 190	Tips and whole sections of branches progressively die and turn brown; affected needles usually remain attached to the branches; symptoms are frequently uniformly distributed over the shrub and are most obvious in spring or early summer; immature or newly expanding needles are most susceptible; upon close inspection, black fruiting bodies of these fungi are evident in browned tissues; microscopic examination is necessary to differentiate these causal fungi.	• prune and remove infected twigs and branches; • avoid overhead irrigation and excessive crowding; • severely infected plants should be rogued and removed; • maintain vigor; • fungicide sprays can be applied as new growth emerges in spring and repeated at label intervals until growth is fully expanded and mature.	chlorothalonil mancozeb mancozeb + copper hydroxide thiophanate-methyl

Thuja (Arborvitae) cont'd

Disease *(Pathogen/Cause)*	Diagnostic Symptoms	Management	Materials
Winter Injury *(Abiotic)* p. 498	Browning, dieback, and shriveling of branches and twigs; symptoms can be extensive and are most evident in late winter or early spring as growth resumes; sub-lethal damage to the cambium may also occur and appears in early summer as a sudden, "unexplained" collapse; refer to fact sheet for more detailed information.	• prune and remove symptomatic tissues to minimize secondary invaders and opportunistic pests; • maintain vigor; • provide adequate moisture in the root zone before the ground freezes; • provide physical (e.g., burlap wraps) and/or chemical (e.g., applications of anti-transpirants) protection in wind-swept areas or in areas prone to extreme temperature fluctuations during the winter; this is especially important for new transplants.	No chemical control is suggested.

Tilia (Basswood, Linden)

Disease *(Pathogen/Cause)*	Diagnostic Symptoms	Management	Materials
Anthracnose *(Glomerella)*	Irregular, brown to reddish-brown areas develop along and sometimes between veins and at leaf margins; symptoms are very similar to those associated with drought and heat stress; some defoliation may occur when infection is heavy; occasional tip dieback.	• rake and remove fallen leaves; • prune dead twigs and branches; • chemical control is usually not necessary except for new transplants, young or specimen trees, or when defoliation has been heavy for several years; fungicide sprays can be applied at budbreak and repeated 2-3 times at label intervals.	mancozeb mancozeb + copper hydroxide propiconazole thiophanate-methyl
Botryosphaeria Canker *(Botryosphaeria)* p. 120	Symptoms include progressive dieback of twigs and branches, usually first evident on lower limbs and proceeding up the tree; cankers appear as sunken areas of bark on branches or the main trunk.	• prune and remove symptomatic twigs and branches as soon as evident; • cuts should be made below visible symptoms when bark is dry; • maintain vigor since drought-stressed or winter-injured trees are more vulnerable; • avoid mechanical injuries; • maintain vigor.	No chemical control is suggested.
Leaf Blotch *(Didymosphaeria)* p. 36	Irregular lesions with somewhat feathery margins first appear water-soaked then change to brown; symptoms are usually delayed and appear in midsummer; diseased leaves shrivel and drop prematurely; heavily infected trees are defoliated by September.	• rake and remove fallen leaves; • prune dead twigs and branches; • chemical control is usually not necessary except for new transplants, young or specimen trees, or when defoliation has been heavy for several years; fungicide sprays can be applied at budbreak and repeated 2-3 times at label intervals.	copper hydroxide mancozeb mancozeb + copper hydroxide propiconazole thiophanate-methyl

Tilia (Basswood, Linden) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Nectria Canker *(Nectria* and *Neonectria)* p. 176	Symptoms include progressive dieback of twigs and branches, usually first evident on lower limbs and proceeding up the tree; cankers appear as sunken areas of bark on branches or the main trunk; brightly colored coral or reddish-orange fruiting structures of the fungus may be visible in the cankers.	• prune and remove symptomatic twigs and branches as soon as evident; • cuts should be made below visible symptoms when bark is dry; • maintain vigor since drought-stressed or winter-injured trees are more vulnerable; • avoid mechanical injuries; • maintain vigor.	No chemical control is suggested.
Powdery Mildew *(Erysiphe)* p. 8	White to grayish, powdery growth on leaves, usually first evident on upper leaf surfaces but can occur on both surfaces of leaves; develops fairly late in the season; some premature fall coloration and leaf drop may occur; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • avoid excessive fertilization since tender, succulent leaves are more susceptible; • provide good air circulation around the tree; • spraying is usually not necessary since the disease has no significant impact on tree health; on specimen trees, fungicides can be applied as soon as symptoms are evident and repeated as necessary.	copper sulphate pentahydrate *potassium bicarbonate propiconazole thiophanate-methyl
Verticillium Wilt *(Verticillium* spp.*)* p. 242	Flagging or wilting of individual limbs or portions of the canopy, usually in midsummer; leaves can be undersized and infected trees sometimes have heavy seed set; trees die slowly or suddenly, depending on the extent of infection and overall health of the tree; a distinctive olive-brown streaking may be evident in the wood of symptomatic branches or twigs; laboratory examination and culturing are usually required for definitive identification; refer to fact sheet for more detailed information.	• prune and remove affected limbs as soon as symptoms are evident; • disinfest tools between cuts; • promote tree vigor; • avoid drought stress; • do not replant susceptible species in the area since the fungus is soilborne (refer to list of resistant species, Table 1).	No chemical control is suggested.

Tsuga (Hemlock)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Cytospora Canker *(Cytospora/Valsa)* p. 166	Symptoms include progressive dieback of twigs and branches, usually first evident on lower limbs and proceeding up the tree; cankers appear as sunken areas of bark on branches or the main trunk but are often very difficult to see; needle browning and drop may occur on infected, girdled branches.	• prune and remove symptomatic twigs and branches as soon as evident; • cuts should be made at least 8-10 inches below visible symptoms when bark is dry; • maintain vigor since drought-stressed or winter-injured trees are more vulnerable; • take care in selecting planting site; • avoid mechanical injuries.	No chemical control is suggested.
Dieback and Decline *(Abiotic)* p. 492	Needles yellow and brown and branch tips die back; this typically occurs in mid- to late summer but can appear in spring when new growth begins; symptoms are often most apparent on current-season needles but can occur on older needles and branches; significant needle drop can occur; no fruiting structures are evident in affected needles; symptoms can be random or uniformly distributed throughout the canopy; hemlocks are particularly sensitive to drought, high temperatures, and heavy shade.	• avoid drought stress and maintain tree vigor; • prune dead branches to avoid secondary invaders or opportunistic pests; • mulch to moderate soil temperatures; • avoid planting on rocky slopes or areas where root penetration into the soil is limited; • give root system a deep soaking before the ground freezes.	No chemical control is suggested.

Tsuga (Hemlock) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Needle Rust *(Melampsora)* p. 286	Several rust species infect hemlock; one species is autoecious and completes its life cycle on hemlock; another species requires members of *Populus* as alternate hosts; symptoms can develop on cones, needles, and green shoots; initial symptoms appear in late spring on newly emerged tissues; affected shoots are curled, slightly swollen, or twisted; bright orangy-yellow, powdery spores cover the affected tissues; infected shoots gradually turn brown and shrivel.	• maintain vigor; • prune dead twigs when necessary; • spraying is usually not necessary since the disease has no significant impact on plant health; on specimen plants, fungicides can be applied as soon as symptoms are evident and repeated as necessary.	azoxystrobin mancozeb triadimefon
Sirococcus Tip Blight *(Sirococcus tsugae)* p. 118	Symptoms first appear on succulent shoots current -year twigs; the fungus attacks at needle bases, girdles the shoot, and results in tip dieback; affected tips turn brown, drop needles, and often develop a characteristic crook or droop; pinpoint, brown fruiting structures may be visible along the stems of dead shoots; affected tips can appear at random in the canopy and often remain attached to the branch for several months.	• prune and remove infected shoots when bark is dry; • rogue and remove heavily infected trees; • maintain vigor; • <u>fungicide sprays are usually not suggested</u>; however, for new transplants or young specimen trees, fungicide sprays can be applied when needles are ½ inch long and repeated 2-4 times at label intervals until needles are fully expanded.	azoxystrobin chlorothalonil mancozeb mancozeb + copper hydroxide thiophanate-methyl

Ulmus (Elm)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Bacterial Wetwood and Slime Flux *(Bacteria and yeasts)* p. 384	This disease complex is usually not an important problem for landscape trees but it can cause unsightly and unpleasant conditions for homeowners; wet streaks are visible on the outer bark of the main trunk where liquids seep out of cracks or fissures in the bark; depending on the organisms responsible, the ooze can be bubbly, amber, and have a foul odor, or it can be colorless and have an “alcoholic,” fermentative odor; oozing can be extensive at certain times of the year; the slime can be toxic to the cambium; when these tissues are killed, additional cracks may develop; some discoloration of the wood may occur but there are usually no symptoms in the canopy.	• maintain vigor • wash off oozing liquid with a stiff spray of water; • do not insert pipes or drainage tubes to relieve pressure.	No chemical control is suggested.
Black Spot *(Stegophora ulmea)* p. 96	Small, yellow spots first appear on upper leaf surfaces early in the season; these spots gradually darken and develop into raised, black spots with yellow halos; when numerous, the spots coalesce and can cause distortion; in wet years, lesions may also form on petioles and succulent stems resulting in a blighted appearance; severe infections can result in near-complete defoliation in early August; this disease is most problematic after wet spring weather and has been very heavy for the past few years.	• rake and remove fallen leaves; • prune and remove symptomatic, blighted tips; • maintain vigor; • provide adequate spacing to allow good air circulation; • fungicide sprays can be applied at budbreak and repeated 2-4 times at label intervals.	mancozeb mancozeb + copper hydroxide

Ulmus (Elm) cont'd

Disease *(Pathogen/Cause)*	Diagnostic Symptoms	Management	Materials
Canker *(Botryosphaeria)* p. 120	Bark of infected twigs appears water-soaked and develops slightly swollen or sunken lesions; inner bark becomes reddish-brown or blackened; small twigs are frequently girdled and killed; cankers on older branches can become perennial and are elliptical; more common on trees under stress from drought or winter injury.	• maintain tree vigor; • prune and remove symptomatic twigs and branches back to sound wood when bark is dry.	No chemical control is suggested.
Dutch Elm Disease *(Ophiostoma novo-ulmi)* p. 240	Symptoms of this historically important disease include “flagging” of individual branches or limbs in midsummer due to yellowing, wilting, and premature drop of leaves; progressive involvement of other parts of the crown continues from year to year since the pathogen is systemic in the tree; branches may die within a few weeks or over several years; diagnostic brown streaks may be visible in the sapwood of symptomatic twigs although their absence does not indicate lack of infection; disease is spread through root grafts and through the activities of two bark beetles, *Hylurgopinus rufipes* and *Scolytus multistriatus*; laboratory examination and culturing of the fungus are usually required for definitive identification.	• prune and remove symptomatic limbs at least 5-10 feet below visible symptoms or vascular streaking; • promptly remove highly symptomatic trees and any dead elm wood in the vicinity (approx. 700 feet) to eliminate places for elm bark beetles to breed and acquire the pathogen; • control bark beetles; refer to the *Pesticide Guide Toward Integrated Pest Management for Connecticut Arborists* for information on specific insecticides; • avoid root grafts; • maintain overall vigor; • resistant cultivars (e.g., ‘Valley Forge,’ ‘New Harmony,’ ‘Liberty’) and species (e.g., Siberian, Chinese) are available; • fungicides can be applied as injections when infections are recognized early (e.g., when no more than 5-10% of the canopy is symptomatic).	copper sulphate pentahydrate debacarb + carbendazim propiconazole thiabendazole

Ulmus (Elm) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Leaf Blister *(Taphrina)* p. 4	Slightly raised, thickened, yellow spots or blisters develop on leaves shortly after emergence; some leaf drop can occur when infection is heavy.	• maintain vigor; • spraying is usually not necessary; however, on specimen or newly transplanted trees, fungicide sprays can be applied before buds begin to swell in spring.	chlorothalonil + thiophanate-methyl mancozeb
Powdery Mildew *(Erysiphe)* p. 8	White to grayish, powdery growth develops on leaves; usually most visible on the upper surfaces of leaves; usually develops fairly late in the season; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • spraying is usually not necessary since the disease has no significant impact on tree health; on specimen trees, fungicides can be applied as soon as symptoms are evident and repeated as necessary.	chlorothalonil chlorothalonil + thiophanate-methyl mancozeb + thiophanate-methyl myclobutanil propiconazole *sulfur thiophanate-methyl triadimefon

Ulmus (Elm) cont'd

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Yellows *('Candidatus* Phytoplasma ulmi'*)* p. 390	Very difficult to diagnose from symptoms, although they include epinasty and yellowing of leaves throughout the crown of the tree; leaves can drop prematurely in midsummer; this is often followed by branch death; symptomatic trees can die within one year of first symptoms or can persist for several years; root mortality is a key part of the disease syndrome, since they are killed very early in disease development; infected wood can have a yellowy-butterscotch color and a supposed unique wintergreen odor when freshly cut; dead phloem has a very dark color; phloem-feeding leafhoppers are thought to transmit the phytoplasma from tree to tree; this disease was formerly called "Elm Phloem Necrosis;" often confused with Dutch Elm Disease; requires molecular laboratory confirmation.	• rogue and remove highly symptomatic trees; • maintain vigor; • tolerant species are available (e.g., 'Homestead' elm, European and Asiatic species, other hybrids); • antibiotic injections of oyxtetracycline are registered but not encouraged.	No chemical control is suggested.

Viburnum (Viburnum)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Bacterial Blight *(Pseudomonas syringae* pv. *syringae)* p. 368	Leaves, shoots, and sometimes flower clusters shrivel and die; first symptoms are irregular to circular, black, water-soaked spots with occasional yellow halos; spots coalesce and leaves develop a blighted appearance; petioles and tender stems become infected, turn brown to black, and droop; elongate, black cankers often develop on current-season wood; blighted tissues usually persist on the tree; symptoms are very similar to frost injury; particularly problematic during cool, wet spring weather; often requires microscopic examination for identification to distinguish from winter or other injuries.	• prune symptomatic leaves and shoots well below obvious symptoms as soon as possible; • disinfest tools between cuts; • maintain vigor but avoid excessive fertilization; • protectant sprays can be applied as new growth emerges in spring and repeated as necessary according to label directions;.	copper hydroxide
Botryosphaeria Canker *(Botryosphaeria)* p. 120	Wilting and dieback are first apparent on individual limbs but may encompass the entire shrub; leaves usually droop and brown yet remain attached to the stem; discolored cankers appear on killed stems or branches.	• prune and remove symptomatic twigs and branches when bark is dry; • avoid wounds and drought stress since the fungus is more aggressive on plants that have been weakened by drought or winter injuries.	No chemical control is suggested.

Viburnum (Viburnum) cont'd

Disease *(Pathogen/Cause)*	Diagnostic Symptoms	Management	Materials
Downy Mildew *(Plasmopara viburni)* p. 352	Initial symptoms appear as light green spots on upper leaf surfaces; spots enlarge and develop into angular reddish brown, necrotic patches between the leaf veins; sporulation of the pathogen is visible on lower leaf surfaces as downy (fuzzy) gray white growth; infected leaves brown, shrivel, and drop prematurely; the pathogen overwinters as resting structures in dead plant tissues; this disease is most serious during cool and warm (not hot) weather with dew or moist conditions.	• rake and remove fallen leaves; • maintain vigor; • spraying is usually not necessary, but fungicide sprays can be applied on a preventative basis as soon as new growth emerges and repeated as necessary according to label directions.	copper hydroxide + mancozeb mancozeb
Powdery Mildew *(Erysiphe)* p. 8	White to grayish, powdery growth on leaves, usually first evident on upper leaf surfaces but can occur on both surfaces of leaves; develops fairly late in the season; some premature fall coloration and leaf drop may occur; refer to fact sheet for more detailed information.	• rake and remove fallen leaves; • avoid excessive fertilization since tender, succulent leaves are more susceptible; • provide good air circulation around the tree; • spraying is usually not necessary since the disease has no significant impact on tree health; on specimen trees, fungicides can be applied as soon as symptoms are evident and repeated as necessary.	chlorothalonil chlorothalonil + iprodione copper sulphate pentahydrate myclobutanil *potassium bicarbonate thiophanate-methyl triadimefon

Zelkova (Zelkova)

Disease *(Pathogen/Cause)*	**Diagnostic Symptoms**	**Management**	**Materials**
Nectria Canker *(Nectria* spp.*)* p. 176	Symptoms include progressive dieback of twigs and branches, usually first evident on lower limbs and proceeding up the tree; cankers appear as sunken areas of bark on branches or the main trunk; brightly colored coral or reddish-orange fruiting structures of the fungus may be visible in the cankers.	• prune and remove symptomatic twigs and branches as soon as evident; • cuts should be made below visible symptoms when bark is dry; • maintain vigor since drought-stressed or winter-injured trees are more vulnerable; • avoid mechanical injuries; • maintain vigor.	No chemical control is suggested.

Table 1. Resistance of Selected Woody Ornamentals to Verticillium Wilt

Resistant or Immune		Susceptible
Apple *(Malus)*	Serviceberry *(Amelanchier)***	Ash *(Fraxinus)*
Arborvitae *(Thuja)*	Spruce *(Picea)*	Azalea *(Rhododendron)*
Beech *(Fagus)*	Sweetgum *(Liquidambar)*	Barberry *(Berberis)*
Birch *(Betula)*	Sycamore *(Platanus)*	Black Locust *(Robinia)*
Boxwood *(Buxus)*	Walnut *(Juglans)*	Box Elder *(Acer negundo)*
Butternut *(Juglans)*	Willow *(Salix)*	Boxwood *(Buxus)*
Crabapple *(Malus)*	Yew *(Taxus)*	Catalpa *(Catalpa)*
Dogwood *(Cornus)***		Cherry, other stone fruits *(Prunus)*
Fir *(Abies)*		Coffee tree, Kentucky *(Gymnocladus)*
Firethorn *(Pyracantha)*		Currant *(Ribes)*
Gingko *(Gingko)*		Dogwood *(Cornus)***
Hackberry *(Celtis)*		Elm *(Ulmus)*
Hawthorn *(Crataegus)*		Honeysuckle *(Lonicera)*
Hickory *(Carya)*		Lilac *(Syringa)*
Holly *(Ilex)*		Linden *(Tilia)***
Honeylocust *(Gleditsia)*		Magnolia *(Magnolia)*
Hornbeam *(Carpinus)*		Maple *(Acer)*
Juniper *(Juniperus)*		Redbud *(Cercis)*
Katsura-tree *(Cercidiphyllum)*		Rose *(Rosa)*
Larch *(Larix)*		Russian Olive *(Elaeagnus)*
Linden *(Tilia)***		Serviceberry *(Amelanchier)***
Mountain Ash *(Sorbus)*		Smoke tree *(Cotinus)*
Mulberry *(Morus)*		Spirea *(Spirea)*
Oak *(Quercus)*		Sumac *(Rhus)*
Pear *(Pyrus)*		Viburnum *(Viburnum)*
Pine *(Pinus)*		Weigela *(Weigela)*
Poplar *(Populus)*		Yellowwood *(Cladratis)*

* The resistance or susceptibility of these plants will depend on the cultivar and strain of *Verticillium* present in the soil.

Table 2. Reaction of Selected Woody Ornamentals to Crown Gall

Not Susceptible	Susceptible (over 77 genera and 32 familes)
Bald Cypress *(Taxodium)*	Apple *(Malus)*
Barberry *(Berberis)*	Birch *(Betula)*
Beech *(Fagus)*	Crabapple *(Malus)*
Blackgum *(Nyssa)*	Dogwood *(Cornus)*
Boxwood *(Buxus)*	Elm *(Ulmus)*
Cryptomeria *(Cryptomeria)*	Euonymus *(Euonymus)*
Deutzia *(Deutzia)*	Honeysuckle *(Lonicera)*
Douglas-fir *(Pseudotsuga)*	Lilac *(Syringa)*
Gingko *(Gingko)*	Peach, Cherry *(Prunus)*
Goldenrain Tree *(Koelreuteria)*	Rose *(Rosa)*
Hemlock *(Tsuga)*	Walnut *(Juglans)*
Holly *(Ilex)*	Willow *(Salix)*
Hornbeam *(Carpinus)*	
Larch *(Larix)*	
Littleleaf Linden *(Tilia)*	
Magnolia *(Magnolia)*	
Pine *(Pinus)*	
Serviceberry *(Amelanchier)*	
Spruce *(Picea)*	
True Cedars *(Cedrus)*	
Tuliptree *(Liriodendron)*	
Yellowwood *(Cladratis)*	
Yew, Japanese *(Taxus)*	
Zelkova *(Zelkova)*	

QUICK REFERENCE FOR PESTICIDES

Trade Name	Common Name
3336 EG	Thiophanate-Methyl
3336 F	Thiophanate-Methyl
4 Flowable Mancozeb	Mancozeb
Agri-Fos 400	Mono- and Di-Potassium Salts of Phosphorous Acid
Agri-Fos Systemic	Mono- and Di-Potassium Salts of Phosphorous Acid
Alamo	Propiconazole
Aliette WDG	Fosetyl-Al
Allban 50 WSB	Thiophanate-Methyl
Allban Flo	Thiophanate-Methyl
Alude	Mono- and Di-Potassium Salts of Phosphorous Acid
ArborFos HP	Mono- and Di-Potassium Salts of Phosphorous Acid
Arbor-OTC	Oxytetracycline Hydrochloride
Arbortect 20-S	Thiobendazole Hypophosphite
Banner MAXX	Propiconazole
Bayleton 50 T/O WSP	Triadimefon
Bayleton Flo T&O	Triadimefon
*Bonide Copper	Copper Sulfate
Cavalier F T&O	Thiophanate-Methyl
Chipco 26019 Flo	Iprodione
Compass Fungicide	Trifloxystrobin
CuPRO 2005 T/N/O	Copper Hydroxide
CuPRO 5000	Copper Hydroxide
Daconil Ultrex	Chlorothalonil
Daconil Weather Stik	Chlorothalonil
Daconil Zn	Chlorothalonil
Docket DF	Chlorothalonil
Docket WS	Chlorothalonil
Eagle 20 EW	Myclobutanil
Eagle 40 WP	Myclobutanil
Echo 720 T&O	Chlorothalonil
Echo Ultimate T&O	Chlorothalonil
*Eco-Mate Armicarb O	Potassium Bicarbonate
Ensign 82.5% T & O	Chlorothalonil
Fore 80 WP Rainshield	Mancozeb
Fosal Select	Fosetyl-Al
Fosphite	Mono- and Di-Potassium Salts of Phosphorous Acid
Fungisol	Debacarb + Carbendazim
FungoFlo	Thiophanate-Methyl
*GreenCure	Potassium Bicarbonate
Heritage	Azoxystrobin
Iprodione 2 SE Select	Iprodione
*JMS Stylet Oil	Horticultural Oil
Junction	Mancozeb + Copper Hydroxide
Lime Sulfur Solution	Calcium Polysulfide
Mainsail 6.0 F	Chlorothalonil

* Biorational fungicide suitable for low-input disease management program.

QUICK REFERENCE FOR PESTICIDES (Cont'd)

Trade Name	Common Name
Mainsail WDG	Chlorothalonil
Mancozeb DG T&O	Mancozeb
Manicure 6 FL T&O	Chlorothalonil
Manicure Ultra T&O	Chlorothalonil
*Micro Sulf	Sulfur
*Microthiol Disperss	Sulfur
*MilStop	Potassium Bicarbonate
*Monterey Hort Oil	Horticultural Oil
Mycoject Ultra	Oxytetracycline Hydrochloride
OHP 6672 4.5 L	Thiophanate-Methyl
OHP 6672 50 WP	Thiophanate-Methyl
OHP Chipco 26019 N/G	Iprodione
*Organic JMS Stylet Oil	Horticultural Oil
Pentathlon LF	Mancozeb
Phostrol	Phosphorous Acid
Phyton 27	Copper Sulphate Pentahydrate
Primera Magellan	Phosphorous Acid
PrimeraOne Chlorothalonil 720 SFT	Chlorothalonil
ProconZ	Propiconazole
Protect DF	Mancozeb
Quali-Pro Chlorothalonil 720 SFT	Chlorothalonil
Quali-Pro Chlorothalonil DF	Chlorothalonil
Quali-Pro Enclave	Thiophanate-Methyl + Chlorothalonil + Iprodione + Tebuconazole
Quali-Pro Fosetyl-Al	Fosetyl-Al
Quali-Pro Ipro 2 SE	Iprodione
Quali-Pro Mefenoxam 2 AQ	Mefenoxam
Quali-Pro Myclobutanil 20 EW T&O	Myclobutanil
Quali-Pro Propiconazole 14.3	Propiconazole
Quali-Pro Quali-Phite F	Mono- and Di-Potassium Salts of Phosphorous Acid
Quali-Pro TM 4.5	Thiophanate-Methyl
Quali-Pro TM 8.5 WDG	Thiophanate-Methyl
Quali-Pro TM/C WDG	Chlorothalonil + Thiophanate-methyl
Riverdale Magellan	Phosphorous Acid
Rubigan AS T&O	Fenarimol
Spectator T&O	Propiconazole
Spectator Ultra 1.3	Propiconazole
Spectro 90 WDG	Chlorothalonil + Thiophanate-methyl
Subdue MAXX	Mefenoxam
*Sulfur 6L	Sulfur
*Sulfur Plant Fungicide	Sulfur
*Sunspray 6E	Horticultural Oil
T-Methyl 4.5 F AG	Thiophanate-Methyl
Twosome	Chlorothalonil + Iprodione
Zyban WSB	Mancozeb + Thiophanate-methyl

* Biorational fungicide suitable for low-input disease management program.

COMMON AND TRADE NAMES OF FUNGICIDES

AZOXYSTROBIN

Trade Name	Company	EPA Registration No.	R.E.I.
Heritage	Syngenta Crop Protection, LLC.	100-1093	4

CALCIUM POLYSULFIDE

Trade Name	Company	EPA Registration No.	R.E.I.
Lime Sulfur Solution	Miller Chemical & Fertilizer Co.	61842-30-72	48

CHLOROTHALONIL

Trade Name	Company	EPA Registration No.	R.E.I.
Daconil Ultrex	Syngenta Crop Protection, LLC.	50534-202-100	12
Daconil Weather Stik	Syngenta Crop Protection, LLC.	50534-209-100	12
Daconil Zn	Syngenta Crop Protection, LLC.	50534-211-100	12
Docket DF	Syngenta Crop Protection, LLC.	50534-202-100	12
Docket WS	Syngenta Crop Protection, LLC.	50534-209-100	12
Echo 720 T&O	Sipcam Agro USA, Inc.	60063-7	12
Echo Ultimate T&O	Sipcam Agro USA, Inc.	60063-3	12
Ensign 82.5% T & O	Loveland	34704-965	12
Mainsail 6.0 F	PROKoZ, Inc.	72112-6	12
Mainsail WDG	PROKoZ, Inc.	72112-5	12
Manicure 6 FL T&O	Lesco, Inc.	60063-7-10404	12
Manicure Ultra T&O	Lesco, Inc.	60063-3-10404	12
PrimeraOne Chlorothalonil 720 SFT	Sipcam Agro USA, Inc.	60063-7	12
Quali-Pro Chlorothalonil 720 SFT	Makhteshim Agan of N. America, Inc.	66222-154	12
Quali-Pro Chlorothalonil DF	Makhteshim Agan of N. America, Inc.	66222-149	12

CHLOROTHALONIL + IPRODIONE

Trade Name	Company	EPA Registration No.	R.E.I.
Twosome	Lesco, Inc.	228-630-10404	24

CHLOROTHALONIL + THIOPHANATE-METHYL

Trade Name	Company	EPA Registration No.	R.E.I.
Quali-Pro TM/C WDG	Makhteshim Agan of N. America, Inc.	48234-7-66222	--
Spectro 90 WDG	Cleary Chemical, LLC.	1001-72	12

COPPER HYDROXIDE

Trade Name	Company	EPA Registration No.	R.E.I.
CuPRO 2005 T/N/O	SePRO	67690-37	48
CuPRO 5000	SePRO	80289-2-67690	48

COPPER SULFATE

Trade Name	Company	EPA Registration No.	R.E.I.
Bonide Copper	Bonide	4-58	NA

COPPER SULPHATE PENTAHYDRATE

Trade Name	Company	EPA Registration No.	R.E.I.
Phyton 27	Phyton Corporation	49538-2	24/48

DEBACARB + CARBENDAZIM

Trade Name	Company	EPA Registration No.	R.E.I.
Fungisol	JJ Mauget, Co.	7946-14	NA

FENARIMOL

Trade Name	Company	EPA Registration No.	R.E.I.
Rubigan AS T&O	Gowan	10163-274	12

FOSETYL-AL

Trade Name	Company	EPA Registration No.	R.E.I.
Aliette WDG	Bayer Crop Sci. LP	432-890	12
Fosal Select	Prime Source, LLC.	89442-8	12
Quali-Pro Fosetyl-Al	Makhteshim Agan of N. America, Inc.	66222-161	12

HORTICULTURAL OIL

Trade Name	Company	EPA Registration No.	R.E.I.
*Monterey Hort Oil	Lawn & Garden Products, Inc.	48813-1-54705	--
*JMS Stylet Oil	JMS Flower Farms, Inc.	65564-1	4
*Organic JMS Stylet Oil	JMS Flower Farms, Inc	65564-1	4
*Sunspray 6E	HollyFrontier Refining & Marketing	86330-6	--

***** Considered a biorational product

IPRODIONE

Trade Name	Company	EPA Registration No.	R.E.I.
Chipco 26019 Flo	Bayer	432-888	12
Iprodione 2 SE Select	Prime Source, LLC.	89442-13	12
OHP Chipco 26019 N/G	OHP, Inc.	432-889-59807	12
Quali-Pro Ipro 2 SE	Makhteshim Agan of N. America, Inc.	66222-214	12

MANCOZEB

Trade Name	Company	EPA Registration No.	R.E.I.
4 Flowable Mancozeb	Lesco, Inc.	62719-396-10404	24
Fore 80 WP Rainshield	Dow AgroSciences	62719-388	24
Mancozeb DG T&O	Lesco, Inc.	62719-402-10404	24
Pentathlon LF	SePRO	67690-38	24
Protect DF	Cleary Chemical, LLC.	1001-77	24

MANCOZEB + COPPER HYDROXIDE

Trade Name	Company	EPA Registration No.	R.E.I.
Junction	SePRO	67690-35	48

MANCOZEB + THIOPHANATE-METHYL

Trade Name	Company	EPA Registration No.	R.E.I.
Zyban WSB	Everris NA, Inc.	58185-31	24

MEFENOXAM (METALAXYL-M)

Trade Name	Company	EPA Registration No.	R.E.I.
Quali-Pro Mefenoxam 2 AQ	Makhteshim Agan of N. America, Inc.	66222-216	48
Subdue MAXX	Syngenta Crop Protection, LLC.	100-796	--

MONO- AND DI-POTASSIUM SALTS OF PHOSPHOROUS ACID

Trade Name	Company	EPA Registration No.	R.E.I.
Agri-Fos 400	Agrichem	71962-1	4
Agri-Fos Systemic	Lawn & Garden Products, Inc.	71962-54705	NA
Alude	Cleary Chemical LLC.	71962-1-1001	4
ArborFos HP	JJ Mauget Co.	7946-26	NA
Fosphite	JH Biotech, Inc	68573-2	4
Quali-Pro Quali-Phite F	Control Solutions, Inc.	83472-1-53883	4

MYCLOBUTANIL

Trade Name	Company	EPA Registration No.	R.E.I.
Eagle 20 EW	Dow AgroSciences	62719-463	24
Eagle 40 WP	Dow AgroSciences	62719-417	24
Quali-Pro Myclobutanil 20 EW T&O	Makhteshim Agan of N. America, Inc.	66222-185	24

OXYTETRACYCLINE HYDROCHLORIDE

Trade Name	Company	EPA Registration No.	R.E.I.
Arbor-OTC	Arborjet, Inc.	74578-7	12
Mycoject Ultra	JJ Mauget, Co.	7946-32	12

PHOSPHOROUS ACID

Trade Name	Company	EPA Registration No.	R.E.I.
Primera Magellan	Nufarm Americas Inc.	228-387	4
Riverdale Magellan	Riverdale Chemical Co.	228-387	4
Phostrol	Nufarm Americas Inc.	55146-83	4

POTASSIUM BICARBONATE

Trade Name	Company	EPA Registration No.	R.E.I.
*Eco-Mate Armicarb O	Helena	5905-541	4
*GreenCure	H & I Agritech, Inc	70870-1	4
*MilStop	BioWorks, Inc.	70870-1-68539	1

***** Considered a biorational product

PROPICONAZOLE

Trade Name	Company	EPA Registration No.	R.E.I.
Alamo	Syngenta Crop Protection, LLC.	100-741	NA
Banner MAXX	Syngenta Crop Protection, LLC.	100-741	12

PROPICONAZOLE (CONT'D)

ProconZ	Loveland Products, Inc.	34704-879	24
Quali-Pro Propiconazole 14.3	Makhteshim Agan of N. America, Inc.	66222-41	12
Spectator T&O	Lesco, Inc.	100-617-10404	12
Spectator Ultra 1.3	Lesco, Inc.	100-741-10404	12

SULFUR

Trade Name	Company	EPA Registration No.	R.E.I.
*Micro Sulf	Nufarm Americas, Inc	55146-75	NA
*Microthiol Disperss	United Phosphorous, Inc.	70506-187	24
*Sulfur 6L	Arysta LifeScience N. America, LLC.	66330-211	--
*Sulfur Plant Fungicide	Bonide	4-62	NA

***** Considered a biorational product

THIOBENDAZOLE HYPOPHOSPHITE

Trade Name	Company	EPA Registration No.	R.E.I.
Arbortect 20-S	Syngenta Crop Protection, LLC.	100-892	NA

THIOPHANATE-METHYL

Trade Name	Company	EPA Registration No.	R.E.I.
3336 F	Cleary Chemical, LLC.	1001-69	12
3336 EG	Cleary Chemical, LLC.	1001-89	12
Allban 50 WSB	Everris NA, Inc.	58185-30	12
Allban Flo	Everris NA, Inc.	58185-33	12
Cavalier F T&O	Cleary Chemical, LLC	1001-69	12
FungoFlo	United Phosphorus, Inc.	70506-251	12
OHP 6672 4.5 L	OHP, Inc.	59807-5	12
OHP 6672 50 WP	OHP, Inc.	59807-6	12
Quali-Pro TM 4.5	Makhteshim Agan of N. America, Inc.	66222-134	--
Quali-Pro TM 8.5 WDG	Makhteshim Agan of N. America, Inc.	66222-145	--
T-Methyl 4.5 F AG	Arysta LifeScience N. America, LLC.	87373-10-83520	12

THIOPHANATE-METHYL + CHLOROTHALONIL + IPRODIONE + TEBUCONAZOLE

Trade Name	Company	EPA Registration No.	R.E.I.
Quali-Pro Enclave	Control Solutions, Inc.	53883-309	12

TRIADIMEFON

Trade Name	Company	EPA Registration No.	R.E.I.
Bayleton 50 T/O WSP	Bayer Environ. Sci.	432-1360	12
Bayleton Flo T&O	Bayer Environ. Sci.	432-1445	12

TRIFLOXYSTROBIN

Trade Name	Company	EPA Registration No.	R.E.I.
Compass Fungicide	Bayer Environ. Sci.	432-1371	12

FOR AGRICULTURAL USE ONLY (when product is used to produce agricultural plants on farms, forests, nurseries, or greenhouses):
R.E.I. = **R**estricted.**E**ntry.**I**nterval (in compliance with Worker Protection Standard 40 CFR part 170).

FOR NON-AGRICULTURAL USE:
Consult label for specific instructions on re-entry.

Disease Management Calendar

KEY TO ABBREVIATIONS OF CONTROL TECHNIQUES

Symbol	Techniques for Control
BSp	Begin spray schedule for **prevention** (diseases are common in Connecticut) ***or*** if disease was **severe** the previous year; discontinue when tissue is fully expanded and/or in dry weather
CSp	Continue spraying if wet weather continues; discontinue in dry weather
D	Apply soil drench fungicides to **uninfected** plants
P	Prune and remove prunings from area
P*	Prune at least 12 inches below visible disease and *thoroughly* disinfest all tools with 10% household bleach, 70% alcohol, or a commercially available compound (e.g., Greenshield®); remove all prunings from area
R	Rake and remove fallen leaves or needles
Sp	Begin spray schedule as soon as symptoms appear
X	Remove severely symptomatic plants since once infected, they cannot be cured and may serve as a source of inoculum to infect healthy plants
Dor	Dormant
Bud	Budbreak
Sum	Summer
Aut	Autumn

ANNUAL DISEASE MANAGEMENT CALENDAR

Host Genus	Common Name	Disease	Dor	Bud	Sum	Aut
Abies	Fir	Armillaria Root Rot	P, X			P, X
		Canker	P		P	P
		Diplodia Blight [Sphaeropsis Tip Blight]	P	BSp		P
		Fungal Needlecast		BSp		R
		Phytophthora Root Rot	X	D	D	P, X
		Rusts	P	BSp		
		Sirococcus Tip Blight	P	BSp		P
Acer	Maple	Anthracnose	P	BSp		P, R
		Bleeding Canker	X	BSp	X	X
		Botryosphaeria Canker	P		P	P
		Decline				
		Eutypella Canker	P		P	P
		Fungal Leaf Spot		BSp		R
		Girdling Root				
		Nectria Cankers [Coral Spot Canker, Perennial Canker]	P		P	P
		Powdery Mildew			Sp	R
		Scorch				
		Tar Spot		BSp		R
		Verticillium Wilt	P, X		P	P, X
Aesculus	Buckeye, Horsechestnut	Anthracnose	P	BSp		P, R
		Leaf Blotch		BSp		R
		Powdery Mildew			Sp	R
		Scorch				
Ailanthus	Tree-of-Heaven	Armillaria Root Rot	P, X			P, X
		Verticillium Wilt	P, X		P	P, X
Albizia	Mimosa, Silk-tree	Mimosa Wilt	X			X
		Nectria Canker	P		P	P
Amelanchier	Serviceberry, Shadblow	Brown Rot	P	BSp		P, R
		Entomosporium Leaf Spot		BSp	CSp	R
		Fire Blight	P*	BSp	P*	P*
		Powdery Mildew			Sp	R
		Rusts	P	BSp		
Berberis	Barberry	Bacterial Leaf Spot	P*			P*
		Phytophthora Root Rot	X	D	D	P, X
		Powdery Mildew			Sp	R
Betula	Birch	Anthracnose	P	BSp		P, R
		Armillaria Root Rot	P, X			P, X
		Leaf Blister		BSp		
		Leaf Rust		BSp		
		Perennial Canker	P		P	P
		Powdery Mildew			Sp	R

ANNUAL DISEASE MANAGEMENT CALENDAR (cont'd)

Host Genus	Common Name	Disease	Dor	Bud	Sum	Aut
Buxus	Boxwood	Boxwood Blight	P, X	BSp	CSp	P, X
		Canker and Leaf Blight	P	BSp	CSp	P, R
		Fungal Leaf Spots		BSp		R
		Phytophthora Root Rot	X	D	D	P, X
		Root Nematodes	X	X	X	X
		Winter Injury/Sunscald	P	P		
Carpinus	Hornbeam, Blue Beech	Anthracnose	P	BSp		P, R
		Botryosphaeria Canker	P		P	P
		Nectria Canker	P		P	P
Carya	Hickory	Anthracnose	P	BSp		P, R
		Canker	P		P	P
		Microstroma Leaf Spot and Witches' Broom				
		Powdery Mildew			Sp	R
Castanea	Chestnut	Blight	P	P	P	P
Catalpa	Catalpa	Fungal Leaf Spots		BSp		R
		Powdery Mildew			Sp	R
		Verticillium Wilt	P, X		P	P, X
Cedrus	Atlas Cedar, Deodar Cedar	Armillaria Root Rot	P, X			P, X
		Diplodia Blight [Sphaeropsis Tip Blight]	P	BSp		P
		Phomopsis Blight	P	BSp		P
		Winter Dieback	P			
Celtis	Hackberry	Fungal Leaf Spots		BSp		R
		Powdery Mildew			Sp	R
		Witches' Broom				
Cercidiphyllum	Katsura-tree	Armillaria Root Rot	P, X			P, X
		Botryosphaeria Canker	P		P	P
		Verticillium Wilt	P, X		P	P, X
Cercis	Redbud	Anthracnose	P	BSp		P, R
		Canker and Dieback				
		Fungal Leaf Spots		BSp		R
		Verticillium Wilt	P, X		P	P, X
Chaenomeles	Quince	Canker and Dieback	P			P
		Fire Blight	P*	BSp	P*	P*
		Leaf Spot		BSp		R
		Rusts	P	BSp		
Chamaecyparis	False Cypress, White Cedar	Blight	P			P
		Needle and Tip Blight	P	BSp		P
		Phytophthora Root Rot	X	D	D	P, X
		Tip Blight	P	BSp		P

ANNUAL DISEASE MANAGEMENT CALENDAR (cont'd)

Host Genus	Common Name	Disease	Dor	Bud	Sum	Aut
Cladrastis	Yellowwood	Botryosphaeria Canker	P		P	P
		Powdery Mildew			Sp	R
		Verticillium Wilt	P, X		P	P, X
Cornus	Dogwood	Anthracnose	P	BSp		P, R
		Armillaria Root Rot	P, X			P, X
		Botrytis Blight	P	BSp		P
		Crown Canker	X			X
		Powdery Mildew			Sp	R
		Scorch				
		Spot Anthracnose	P	BSp		P, R
		Tip Blight	P	BSp		P
Corylus	Contorted Walking Stick, Filbert, Hazelnut	Eastern Filbert Blight [Twig Blight/Canker]	P	BSp	P	P
		Powdery Mildew			Sp	R
Cotinus	Smoke Tree	Armillaria Root Rot	P, X			P, X
		Botryosphaeria Canker	P		P	P
		Powdery Mildew			Sp	R
		Verticillium Wilt	P, X		P	P, X
Cotoneaster	Cotoneaster	Canker	P			P
		Fire Blight	P*	P*	P*	P*
Crataegus	Hawthorn	Botrytis Blight	P	BSp		P
		Entomosporium Leaf Spot [Hawthorn Leaf Blight]		BSp	CSp	R
		Fire Blight	P*	BSp	P*	P*
		Powdery Mildew			Sp	R
		Rusts	P	BSp		
		Scab		BSp	CSp	R
Cryptomeria	Cryptomeria, Japanese Cedar	Botryosphaeria Canker	P		P	P
		Leaf Blight	P	BSp		P
		Leaf Spot	P			P
		Winter Injury	P	P		
XCupressocyparis leylandii	Leyland Cypress	Botryosphaeria Canker	P		P	P
		Seiridium Canker	P	P		
		Winter Injury	P	P		
Euonymus	Euonymus	Anthracnose	P	BSp		P, R
		Crown Gall	X			P, X
		Fungal Leaf Spots		BSp		R
		Powdery Mildew			Sp	R
Fagus	Beech	Beech Bark Disease	P, X			X
		Bleeding Canker	P, X	BSp	X	X
		Powdery Mildew			Sp	R
		Sooty Mold				

ANNUAL DISEASE MANAGEMENT CALENDAR (cont'd)

Host Genus	Common Name	Disease	Dor	Bud	Sum	Aut
Forsythia	Forsythia	Bacterial Blight	P*	BSp	P*	P*
		Fungal Leaf Spots		BSp		R
		Gall	P			P
Fraxinus	Ash	Anthracnose	P	BSp		P, R
		Decline	P			P
		Fungal Leaf Spots		BSp		R
		Leaf Rust		BSp		
		Powdery Mildew			Sp	R
		Verticillium Wilt	P, X		P	P, X
		Yellows	X			X
Gleditsia	Honeylocust	Powdery Mildew			Sp	R
		Thyronectria Canker	P		P	P
Hamamelis	Witch Hazel	Botryosphaeria Canker	P		P	P
		Crown Gall	P*			P*, X
		Fungal Leaf Spots		BSp		R
		Powdery Mildew			Sp	R
		Witch Hazel Blight	P, X	BSp	CSp	P, X
Hibiscus	Rose-of-Sharon	Botryosphaeria Canker	P		P	P
		Botrytis Blight	P	BSp	CSp	P
		Canker	P		P	P
		Powdery Mildew			Sp	R
Hydrangea	Hydrangea	Bacterial Blight	P*	P*	P*	P*
		Bacterial Leaf Spot	P	BSp	CSp	P, R
		Botrytis Blight	P	BSp	CSp	P
		Fungal Leaf Spots		BSp		R
		Powdery Mildew			Sp	R
		Winter Dieback	P	P		
Ilex	Holly	Armillaria Root Rot	P, X			P, X
		Botryosphaeria Canker	P		P	P
		Botrytis Blight	P	BSp		
		Fungal Leaf Spots		BSp		R
		Leaf Blotch [Purple Leaf Scorch]				
		Powdery Mildew			Sp	R
		Spine Spot				
		Tar Spot		BSp		R
		Winter Injury/Scorch	P			
Juglans	Black Walnut, Butternut, Walnut	Anthracnose	P	BSp		P, R
		Bacterial Blight	P*	BSp		P*
		Bunch Disease [Witches' Broom]	X			X
		Canker [Butternut Canker]	P		P	P
		Powdery Mildew			Sp	R
		Thousand Cankers Disease	X	X	X	X

ANNUAL DISEASE MANAGEMENT CALENDAR (cont'd)

Host Genus	Common Name	Disease	Dor	Bud	Sum	Aut
Juniperus	Juniper,	Botryosphaeria Canker	P	P		
	Red Cedar	Cercospora Needle Blight	P	P		
		Pestalotiopsis Needle Blight	P	P		
		Phytophthora Root Rot	P, X	D	D	X
		Red Cedar Decline	P			P
		Rusts	P			P
		Tip Blight-Abiotic				
		Tip Blight-Kabatina	P		Sp	P
		Tip Blight-Phomopsis	P	BSp		
Kalmia	Mountain Laurel	Armillaria Root Rot	P, X			P, X
		Botryosphaeria Canker	P		P	P
		Chlorosis				
		Fungal Leaf Spots		BSp		R
		Leaf/Twig Blight	P	BSp		P, R
		Necrotic Ringspot				
		Phytophthora Root Rot	X	D	D	P, X
		Powdery Mildew			Sp	R
		Tip Blight		BSp		
		Winter Injury	P	P		
Koelreuteria	Goldenrain Tree	Armillaria Root Rot	P, X			P, X
		Botryosphaeria Canker	P		P	P
		Canker	P		P	P
		Verticillium Wilt	P, X		P	P, X
Laburnum	Golden-Chain Tree	Botryosphaeria Canker	P		P	P
		Twig Blight	P		P	P
Larix	Larch,	Canker	P		P	P
	Tamarack	Mycosphaerella Needlecast		BSp		R
Leucothoe	Leucothoe	Fungal Leaf Spots		BSp		R
		Powdery Mildew			Sp	R
		Winter Injury	P			
Ligustrum	Privet	Alternaria Leaf Spot		BSp		
		Anthracnose/Twig Blight	P	BSp		P, R
		Armillaria Root Rot	P, X			P, X
		Oedema				
		Powdery Mildew			Sp	R
Liquidambar	Sweetgum	Bleeding Necrosis	P, X			X
		Fungal Leaf Spots		BSp		R
Liriodendron	Tuliptree	Canker	P		P	P
		Fungal Leaf Spots		BSp		R
		Leaf Yellowing				
		Powdery Mildew			Sp	R
		Sooty Mold				
		Verticillium Wilt	P, X		P	P, X

ANNUAL DISEASE MANAGEMENT CALENDAR (cont'd)

Host Genus	Common Name	Disease	Dor	Bud	Sum	Aut
Lonicera	Honeysuckle	Leaf Blight		BSp		R
		Powdery Mildew			Sp	R
Magnolia	Magnolia	Leaf Spots		BSp		R
		Powdery Mildew			Sp	R
		Verticillium Wilt	P, X		P	P, X
Malus	Apple, Crabapple	Botryosphaeria Canker	P		P	P
		Fire Blight	P*	BSp	P*	P*
		Frogeye Leaf Spot [Black Rot]	P	BSp	CSp	P, R
		Nectria Canker	P		P	P
		Powdery Mildew			Sp	R
		Rusts	P	BSp		
		Scab		BSp	CSp	R
Metasequoia	Dawn Redwood	Canker	P		P	P
Morus	Mulberry	Canker	P		P	P
		Fungal Leaf Spots		BSp		R
		Powdery Mildew			Sp	R
Nyssa	Black Gum, Tupelo	Canker	P		P	P
Ostrya	Hop-hornbeam, Ironwood	Armillaria Root Rot	P, X			P, X
		Canker	P		P	P
		Powdery Mildew			Sp	R
Oxydendrum	Sorrel-tree, Sourwood	Botryosphaeria Canker	P		P	P
		Nectria Canker	P		P	P
Paulownia	Empress Tree	Botryosphaeria Canker	P		P	P
Picea	Spruce	Armillaria Root Rot	P, X			P, X
		Botrytis Blight	P	P		P
		Cytospora Canker	P		P	P
		Decline	P			P
		Phomopsis Canker	P			P
		Phytophthora Root Rot	X	D	D	P, X
		Rhizosphaera Needlecast		BSp		R
		Rusts	P	BSp		
		Sirococcus Blight	P	BSp		P
		Stigmina Needlecast/ Needle Blight	P	BSp		
Pieris	Japanese Andromeda, Pieris	Canker and Dieback	P		P	P
		Fungal Leaf Spots		BSp		R
		Phytophthora Root Rot	X	D	D	
		Tip Dieback and Blight	P	BSp		P, X

ANNUAL DISEASE MANAGEMENT CALENDAR (cont'd)

Host Genus	Common Name	Disease	Dor	Bud	Sum	Aut
Pinus	Pine	Armillaria Root Rot	P, X			P, X
		Brown Spot Needle Blight		BSp		R
		Dooks Needle Blight [Canavirgella Needlecast]		BSp		
		Cenangium Blight	P		P	P
		Cyclaneusma Needlecast		BSp		R
		Diplodia Blight [Sphaeropsis Tip Blight]	P	BSp		P
		Dothistroma Needle Blight [Red Banded Needle Blight]		BSp		R
		Lophodermium Needlecast		BSp		R
		Phytophthora Root Rot	X	D	D	P, X
		Pine-Pine Gall Rust	P, X			P, X
		Pine Wood Nematode	X	X	X	X
		Pitch Canker	P		P	P
		Ploioderma Needlecast		BSp		R
		Procerum Root Disease	X			X
		Sirococcus Tip Blight	P	BSp		P
		White Pine Blister Rust	P	P	P	P
		Winter Injury/Drying	P	P		
Platanus	London Plane, Sycamore	Anthracnose	P	BSp		P, R
		Canker and Dieback	P		P	P
		Canker Stain	P		P	P
		Leaf Spots		BSp		R
		Powdery Mildew			Sp	R
Populus	Cottonwood, Poplar	Canker	P		P	P
		Fungal Leaf Spots		BSp		R
		Leaf Blister		BSp		
		Powdery Mildew			Sp	R
		Rust		BSp	CSp	R
Prunus	Cherry, Flowering Cherry, Peach, Plum	Bacterial Canker	P*	BSp		P*
		Black Knot	P	BSp		P
		Brown Rot/Shoot Blight	P	BSp		P, R
		Gummosis				
		Leaf Curl		BSp		
		Leaf Spot [Coccomyces Leaf Spot]		BSp		R
		Powdery Mildew			Sp	R
		Winter Injury	P	P		
		X-Disease	X		X	X
Pseudotsuga	Douglas-Fir	Diplodia Blight [Sphaeropsis Tip Blight]	P	BSp		P
		Rhabdocline Needlecast	X	BSp		P, R
		Swiss Needlecast		BSp		P, R
Pyracantha	Firethorn	Fire Blight	P*	BSp	P*	P*
		Scab		BSp	CSp	R

ANNUAL DISEASE MANAGEMENT CALENDAR (cont'd)

Host Genus	Common Name	Disease	Dor	Bud	Sum	Aut
Pyrus	Pear	Fire Blight	P*	BSp	P*	P*
		Leaf Blister		BSp		
		Leaf Spot [Fabraea Leaf Spot]		BSp	CSp	P, R
		Pear Trellis Rust		BSp	CSp	
		Powdery Mildew			Sp	R
		Scab		BSp	CSp	R
Quercus	Oak	Anthracnose	P	BSp		P, R
		Armillaria Root Rot	P, X			P, X
		Bacterial Wetwood and Slime Flux				
		Biscogniauxia (Hypoxylon) Canker	P		P	P
		Bleeding Canker	X	BSp	X	X
		Botryosphaeria Canker	P		P	P
		Leaf Blister		BSp		
		Oak Wilt	X		X	X
		Powdery Mildew			Sp	R
		Scorch				
		Tubakia Leaf Spot [Actinopelte Leaf Spot]		BSp		R
Rhododendron	Azalea, Rhododendron	Armillaria Root Rot	P, X			P, X
		Botryosphaeria Canker and Dieback	P		P	P
		Botrytis Blight	P	BSp	CSp	P
		Chlorosis				
		Crown Gall	P, X		X	X
		Fungal Leaf Spots		BSp		R
		Gray Blight				
		Leaf Gall	P	BSp		
		Phytophthora Root Rot	X	D	D	D, X
		Phytophthora Tip Dieback/ Blight	P	BSp		P
		Powdery Mildew			Sp	R
		Winter Injury	P	P		
Robinia	Black Locust	Canker				
		Powdery Mildew			Sp	R
Rosa	Rose	Black Spot	P	BSp	CSp	P, R
		Botrytis Blight	P	BSp	CSp	P, R
		Crown Gall	X		P	P, X
		Dieback	P			P, X
		Downy Mildew		BSp	CSp	P
		Powdery Mildew			Sp	R
		Rose Mosaic Virus	X			X
		Rose Rosette Virus	P, X		X	X
		Rose Rust	P	BSp	CSp	P
		Winter Injury	P	P		

ANNUAL DISEASE MANAGEMENT CALENDAR (cont'd)

Host Genus	Common Name	Disease	Dor	Bud	Sum	Aut
Salix	Willow	Canker	P		P	P
		Leaf Rust	P	BSp		P
		Powdery Mildew			Sp	R
		Willow Blight [Black Canker and Scab]	P			P
Sassafras	Sassafras	Anthracnose	P	BSp		P, R
		Armillaria Root Rot	P, X			P, X
		Canker	P		P	P
		Powdery Mildew			Sp	R
		Verticillium Wilt	P, X		P	P, X
Sophora	Japanese Pagoda-tree, Pagoda-tree	Canker and Twig Blight	P		P	P
		Twig Blight	P		P	P
		Verticillium Wilt	P, X		P	P, X
Sorbus	Mountain Ash	Cankers	P		P	P
		Fire Blight	P*	BSp	P*	P*
		Leaf Blotch		BSp		R
		Leaf Spot		BSp		R
		Rusts	P	BSp		
		Scab		BSp	CSp	R
Spirea	Spirea	Fire Blight	P*	P*	P*	P*
		Powdery Mildew			Sp	R
Syringa	Lilac	Ascochyta Blight	P	BSp?		R
		Bacterial Blight	P*	BSp	CSp	P*
		Phytophthora Blight	P	BSp		
		Powdery Mildew			Sp	R
		Witches' Broom	P			P
Taxus	Yew	Armillaria Root Rot	P, X			P, X
		Botryosphaeria Canker	P		P	P
		Dieback	P			
		Oedema				
		Phytophthora Root and Stem Rot	X	D	D	D, X
Thuja	Arborvitae	"Black" Disease				
		Botryosphaeria Canker	P		P	P
		Botrytis Blight	P			P
		Cercospora Blight	P	BSp		
		Diplodia Blight [Sphaeropsis Tip Blight]	P	BSp		P
		Seasonal Needle Browning and Shedding	P			
		Tip Blight	P			P
		Twig Blights	P	BSp		
		Winter Injury	P	P		

ANNUAL DISEASE MANAGEMENT CALENDAR (cont'd)

Host Genus	Common Name	Disease	Dor	Bud	Sum	Aut
Tilia	Basswood,	Anthracnose	P	BSp		P, R
	Linden	Botryosphaeria Canker	P		P	P
		Leaf Blotch	P	BSp		R
		Nectria Canker	P		P	P
		Powdery Mildew			Sp	R
		Verticillium Wilt	P, X		P	P, X
Tsuga	Hemlock	Cytospora Canker	P		P	P
		Dieback and Decline				
		Needle Rust	P	BSp		P, R
		Sirococcus Tip Blight	P			P
Ulmus	Elm	Bacterial Wetwood and Slime Flux				
		Black Spot		BSp		R
		Canker	P		P	P
		Dutch Elm Disease	P, X	P, X	P, X	P, X
		Leaf Blister		BSp		
		Powdery Mildew			Sp	R
		Yellows	X?			X?
Viburnum	Viburnum	Bacterial Blight	P*		P*	P*
		Botryosphaeria Canker	P		P	P
		Downy Mildew		BSp	CSp	
		Powdery Mildew			Sp	R
Zelkova	Zelkova	Nectria Canker	P		P	P

Fact Sheets

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Putting science to work for society

Dr. Sharon M. Douglas
Department of Plant Pathology and Ecology
The Connecticut Agricultural Experiment Station
123 Huntington Street, P. O. Box 1106
New Haven, CT 06504

Phone: (203) 974-8601
Fax: (203) 974-8502
Email: Sharon.Douglas@ct.gov
Website: www.ct.gov/caes

ANTHRACNOSE DISEASES OF TREES

Anthracnose diseases occur on many important shade and ornamental tree species throughout Connecticut every year, although the prevalence and severity of disease can vary with each season, site, and species. Anthracnose diseases are common on ash (*Fraxinus*), maple (*Acer*), oak (*Quercus*), and sycamore (*Platanus*). Less common are anthracnose of beech (*Fagus*), birch (*Betula*), elm (*Ulmus*), walnut (*Juglans*), and linden (*Tilia*). Anthracnose of dogwood (*Cornus*) is a particularly serious disease that is discussed in a separate fact sheet: http://www.ct.gov/caes/lib/caes/documents/publications/fact_sheets/plant_pathology_and_ecology/dogwood_anthracnose.pdf.

Anthracnose diseases are most noticeable on trees in the landscape, but they also occur on trees growing in natural woodlots and forests. These diseases are also called "leaf blights" or "leaf spots." The degree to which each tree or species is affected by disease is influenced by genetic factors, microclimate, and predisposition by other stresses (e.g., site, drought, excess water, winter injury), although water, in the form of rain, dew, or fog, is critical for infection and spread. Therefore, anthracnose diseases are most problematic during periods of extended cool, wet weather as leaves are emerging in spring. The term "anthracnose" refers to diseases caused by fungi that produce spores (conidia) in fruiting structures called acervuli (Figures 1 and 2).

Figure 1. Arrows indicate fruiting structures, called acervuli, that are oozing spores of the sycamore anthracnose fungus.

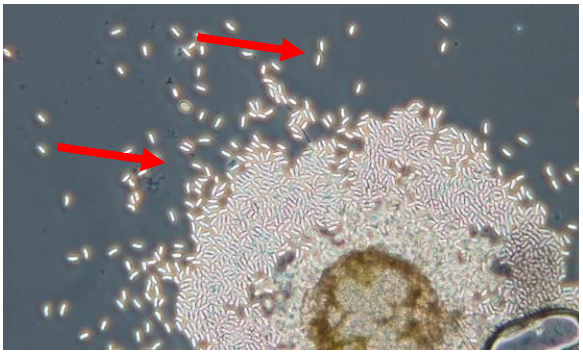

Figure 2. Arrow indicate spores (conidia) of the sycamore anthracnose fungus.

Anthracnose fungi typically overwinter in infected leaves on the ground. However, in some cases (e.g., sycamore anthracnose), the fungus also overwinters in buds, cankered branches, and twigs on the tree. Infections of leaves, flowers, fruit, and stem tissues can occur and are usually initiated in spring when new growth is emerging. However, new infections can also continue throughout the entire season, when the weather is favorable. Environmental conditions that are most favorable for disease development include periods of extended cool, moist, or wet weather.

Symptoms of anthracnose diseases range from minor, cosmetic spotting of leaves, to blighting of leaves and tender shoots, to dieback of twigs and branches. Symptoms also vary with the individual host and the causal fungus. Although symptoms of anthracnose are most obvious from mid-spring to early summer, additional cycles of infection can result in damage that is visible later in the growing season. As leaves and shoots mature and approach full-size, they become relatively resistant to infection.

Anthracnose diseases are generally considered aesthetic or nuisance problems. However, when infections are heavy, they can result in disconcerting levels of premature leaf drop and defoliation. Anthracnose diseases can also disfigure trees when infected twigs and branches die. This is more common after several successive years of disease. Most trees that drop leaves prematurely usually produce new shoots and leaves by mid-summer. Trees that are otherwise healthy can fortunately withstand several years of defoliation without long-term implications for tree health. However, anthracnose diseases can have a greater impact on trees that are newly transplanted or stressed.

ASH ANTHRACNOSE:

Causal Agents: *Gnomoniella fraxini (Discula fraxinea)*

Hosts: *Fraxinus* (black and white ash; green ash is fairly resistant)

Symptoms: Symptoms develop on newly expanding shoots and leaves in spring. Tender shoots are blighted and killed during cool, wet weather. Infections on developing leaves first appear as water-soaked, irregular areas. These develop into brown, somewhat papery lesions (Figure 3). When infections are moderate, only portions of each leaflet are affected.

Figure 3. Symptoms of ash anthracnose. Note angular, necrotic lesions on leaflets that distort the overall appearance of the leaf.

This can give the leaf a distorted appearance, but leaves usually remain attached to the tree. When infections are heavy, entire leaves will turn brown and drop prematurely. Branches that have dropped their leaves usually produce new shoots and leaves by mid-summer.

MAPLE ANTHRACNOSE:

Causal Agents: *Discula* sp., *Kabatiella apocrypta*

Hosts: *Acer* (Japanese, Norway, sycamore, red or swamp, silver, and sugar maple).

Symptoms: Symptoms vary with the species of maple affected. Narrow, purple to brown streaks develop along the veins of leaves of Norway maples, whereas large, brown patches develop between the veins on sugar maple leaves. Symptoms on Japanese maples appear as light tan, papery spots in the leaf or as tan areas at leaf margins. Although symptoms vary with the type of maple, the symptoms that are common to most maples are irregular, dead areas on the leaves (Figures 4 and 5).

Figure 4. Symptoms of maple anthracnose on upper leaf surfaces.

Figure 5. Same leaves as in Figure 4, only this view is of lower leaf surfaces.

These areas can first appear as small spots that eventually enlarge and become V-shaped or delineated or defined by the veins. Affected tissues can be tan to brown and paper-thin (Figure 6). When infection is severe, the fungus enters the petioles and causes entire leaves to appear blighted, browned, and shriveled. Distorted leaves with maple anthracnose can be confused with frost (Figure 7), drought, and heat stress. Samaras can also develop necrotic or dead spots and drop. Significant leaf drop can occur in late spring but trees usually re-foliate by mid-summer.

Figure 6. Close-up of maple anthracnose angular lesion.

Figure 7. Frost damage to Japanese maple. Note marginal necrosis and distortion of the leaves.

BEECH ANTHRACNOSE:

Causal Agents: *Apiognomonia erribunda (Discula umbrinella)*

Hosts: *Fagus* (American and European beech)

Symptoms: Early symptoms of beech anthracnose appear as irregular, brown spots on the leaves that are usually positioned on or between leaf veins (Figures 8 and 9). As the symptoms progress, the dark brown necrotic tissue expands to all interveinal portions of the leaf (Figure 10) and eventually large sections of the leaf become necrotic (Figure 11). Infected leaves will eventually drop from the tree.

Figure 8. Irregular, brown spots between the veins of beech leaves.

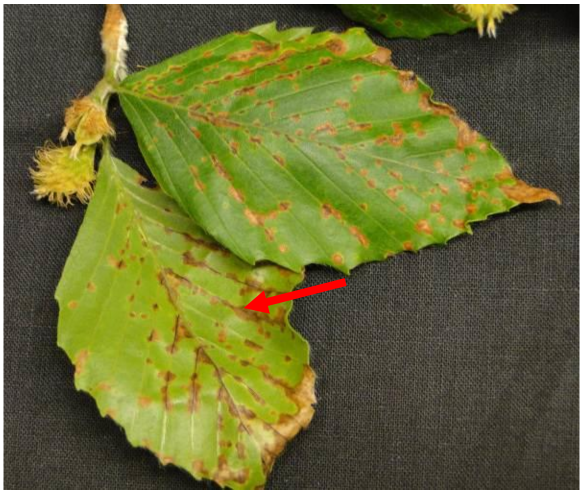

Figure 9. Necrotic lesions along veins of infected leaves (arrow).

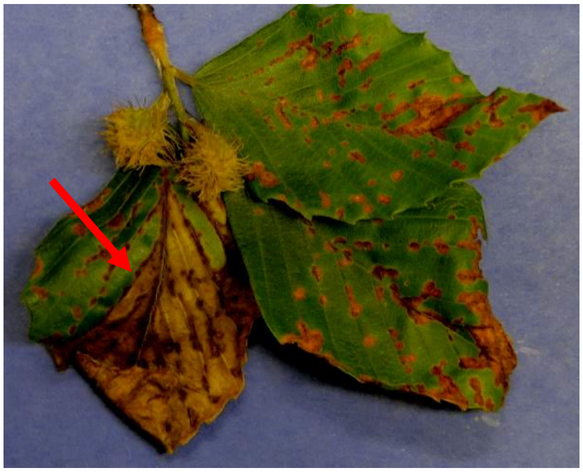

Figure 10. Large, brown blotches appear on heavily infected leaves (arrow).

Beech anthracnose symptoms can be confused with leaf scorch, a physiological disease associated with heat and drought. With anthracnose, the necrotic tissue expands from the inner portions of the leaf outward. With leaf scorch, the browning first appears along the leaf edges and expands inward.

SYCAMORE ANTHRACNOSE:
Causal Agents: *Apiognomonia veneta (Discula platani)*
Hosts: *Platanus* (sycamore, London plane)
Symptoms: Probably the most common of all anthracnose diseases, sycamore anthracnose often occurs in three phases, each of which can result in different types of symptoms: 1) twig and branch cankers, 2) shoot blight, and 3) leaf blight. Weather patterns usually influence the severity of each phase. In the first phase, the fungus overwinters in twigs and buds. This results in cankers and bud death when the trees are dormant. During the shoot blight phase, new shoots are rapidly killed by the fungus as they expand. This symptom is particularly noticeable during or just after cool, wet periods in spring. Infected trees are visible in late spring, since they have distinctly sparse canopies, when compared to surrounding species of healthy trees (Figures

11 and 12). These first two phases can be confused with frost damage.

In the final leaf blight phase, newly expanding leaves are infected and killed as they emerge (Figure 13). Leaves are most susceptible during the first few weeks of growth. Lesions often first appear along the veins of infected leaves (Figure 14). These areas expand into large, brown areas on the leaves (Figure 15) and into the petioles. Significant leaf drop can occur in late spring or early summer, although by mid-summer,

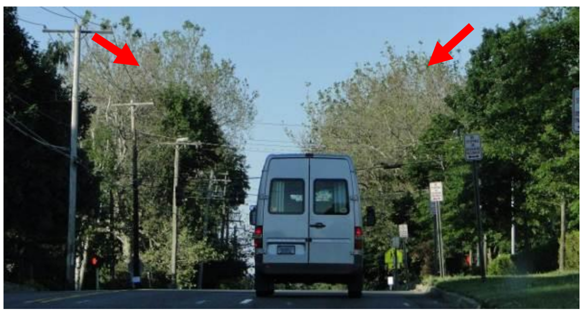

Figure 11. Sycamore trees with anthracnose and sparse canopies (arrows) are easily distinguished from other species of healthy trees with full green canopies in late spring.

Figure 12. Sycamore infections can be recognized by the sparse canopy, as the tree begins to leaf-out in the spring.

most trees will have re-foliated with a canopy of healthy leaves.

Figure 13. Infected leaves brown and drop prematurely.

Figure 14. Lesions of sycamore anthracnose first develop along the veins.

Figure 15. Lesions often enlarge to V-shaped, necrotic areas between veins.

OAK ANTHRACNOSE:

Causal Agents: *Apiognomonia quercina (Discula quercina)*
Hosts: *Quercus* (white, black, pin, burr, and scarlet oak)
Symptoms: White oak is the most susceptible of all oak species. Although some twig and branch dieback can occur, the most common symptom appears as a blighting of newly expanding shoots and emerging leaves. Irregular, tan, papery, necrotic spots develop on the leaves as they develop and are often concentrated along the veins or at the margins of the leaves (Figures 16, 17, and 18).

When the spots are numerous, they coalesce and give the leaves a blighted appearance (Figure 19). Lesions can develop on petioles and green stems as the fungus colonizes these tissues (Figure 20). Heavily infected leaves become distorted and often drop prematurely by late spring or early summer. In most cases, trees are usually re-foliated by late summer.

Figure 16. Irregular, necrotic lesions are concentrated along the veins of oak leaves infected with anthracnose.

Figure 17. Close-up of necrotic anthracnose lesion on white oak.

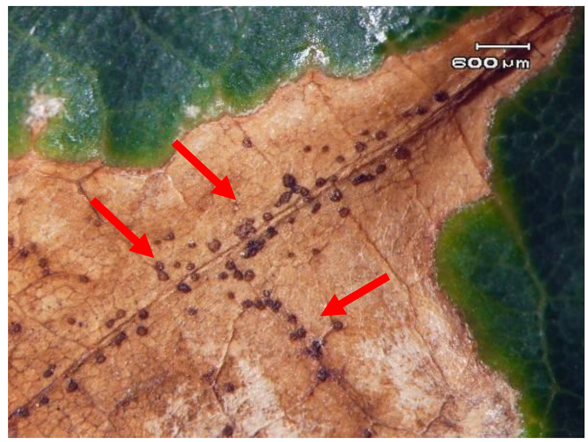

Figure 18. Fruiting bodies (arrows) of the anthracnose fungus along the vein of the lesion in Figure 17.

Figure 19. Heavily infected leaves have a blighted appearance.

Figure 20. Petiole and stem lesions (arrows) on infected white oak.

MANAGEMENT STRATEGIES FOR ANTHRACNOSE DISEASES:

Managing anthracnose diseases is most successful using a multifaceted strategy. These diseases are often effectively controlled by following good sanitary and cultural practices and are rarely serious enough to warrant chemical control.

- Anthracnose fungi overwinter in cankers on twigs and branches and to some extent, on fallen leaves. Because these serve as important sources of overwintering inoculum, symptomatic tissues should be pruned, raked, and/or removed as completely as practical. This practice reduces the number of fungal spores available to infect emerging shoots and leaves in spring and during the growing season.
- Maintain overall tree vigor by following sound cultural practices. These include watering, fertilizing (as determined by a soil test), mulching, and pruning.
- Although anthracnose diseases are usually considered to be more aesthetic than life-threatening, there are situations where they can be serious and cause permanent damage or even tree death. Newly transplanted trees or trees weakened by environmental or site-related stress are particularly sensitive to several years of repeated defoliation. In such cases, chemical control can be beneficial. Among the fungicides registered for homeowner use in Connecticut are thiophanate-methyl, chlorothalonil, copper sulfate pentahydrate, and mancozeb. Organic options for control include copper products, sulfur, *Bacillus subtilis* QST 713 strain (Serenade®), and potassium bicarbonate. The pesticide label will contain information on dosage rates, application intervals, and safety precautions. Since most anthracnose fungi infect in spring as the buds are swelling and new leaves and shoots are expanding, the first fungicide spray is applied at or just prior to bud break. Two or three additional sprays are subsequently applied at intervals specified by the label for the particular fungicide being used. Additional applications may also be necessary under unusually wet or prolonged spring conditions. Once symptoms of anthracnose are visible on the leaves it is usually too late for effective chemical control.

June 2011 (revised)

Dr. Sharon M. Douglas
Department of Plant Pathology and Ecology
The Connecticut Agricultural Experiment Station
123 Huntington Street, P. O. Box 1106
New Haven, CT 06504

Phone: (203) 974-8601
Fax: (203) 974-8502
Email: Sharon.Douglas@ct.gov
Website: www.ct.gov/caes

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ASH LEAF RUST

Ash leaf rust is one of the most spectacular rust diseases of trees in the Northeast. The fungus, *Puccinia sparganoides*, is a heteroecious rust that requires two different species of host plants to complete its life cycle. The two types of hosts are often called primary and secondary (alternate) hosts. The primary hosts (aecial hosts) of ash leaf rust are several species of ash (*Fraxinus* spp.), including white, green, and occasionally, black ash. The secondary hosts (telial hosts) are several species of marsh grass (*Spartina* spp.) and cordgrass (*Distichlis spicata*). Ash leaf rust appears to run in cycles of approximately 5-7 years.

SYMPTOMS AND DISEASE CYCLE:

Ash leaf rust is most severe along the New England coast, locations where the fungus reproduces and overwinters on grasses in salt marshes. In spring, clouds of rust spores are produced on these hosts. They move inland from the marshes and infect newly emerging leaves of ash. Severe rust often develops on ash after periods of foggy, windy weather with onshore airflow. In epidemic years, symptoms of ash leaf rust have been observed as far as 48 km inland.

Infection of ash occurs on leaves, petioles, and green twigs during May and June. Leaflets and leaves are conspicuously distorted and diseased tissues swell by mid to late June. These cause sharp bends in the petioles and elliptic, wart-like galls on green twigs (Figure 1).

Figure 1. Extensive rust symptoms on ash petioles that result in a distortion of the leaves.

Spots on leaflets may enlarge to several millimeters in diameter (Figure 2). Heavily infected trees can look scorched, as petiole infections lead to withering and browning of leaves in early summer.

Defoliation can result when infection is severe. Spores of this rust fungus appear as bright orange or yellow powdery masses that are produced in tiny cup-like structures (Figures 3 and 4). These spores are incapable of reinfecting ash trees, but re-infect the marsh or cord grass hosts in July and August.

Figure 2. Diagnostic rust pustules that distort infected ash leaflets.

Figure 3. Tiny cup-like fruiting structures on ash containing spores that can only infect marsh or cord grass hosts.

Elongate, swollen fruiting structures develop on the grass hosts in July and August. The fungus multiplies and builds up on the grass hosts in late summer. Because rust infections on these hosts are difficult to detect, the disease can reach epidemic levels in one season under favorable conditions. Late in the summer, these fruiting structures change into another type of fruiting body that produces resting spores. The rust fungus then overwinters in the marshes on these grasses. In spring, the cycle begins again as spores produced on the grass hosts move inland to infect the ash hosts. These spores are carried by the wind to newly emerging ash leaves and twigs.

Figure 4. Close-up of powdery spores in cup-like fruiting bodies on ash

CONTROL:

Ash leaf rust is rarely destructive enough to warrant special control measures. Defoliation may be heavy in some years, but it usually occurs in early summer and is thought to do no significant damage to otherwise healthy trees. However, successive years of severe rust infections can weaken trees, make them susceptible to winter damage, and cause dieback. Infections are particularly problematic on landscape trees. This disease has been reported to kill very young trees. In these cases, it is important to maintain the overall vigor of infected trees by following sound cultural practices that include watering during periods of drought, mulching, and fertilizing, as determined by soil or tissue analyses.

A final strategy for disease management involves the proper selection, timing, and application of fungicide sprays. Thorough coverage of all parts of the tree is necessary and the sprays should be applied until run-off. The fungicide label will contain information on dosage rates and safety precautions. Among the fungicides registered for use in Connecticut are chlorothalonil, mancozeb + myclobutanil, myclobutanil, thiophanate methyl, and thiophanate methyl + chlorothalonil. An organic management option is QST 713 strain of *Bacillus subtilis*. Fungicides can be applied at budbreak and repeated 2-3 times as necessary.

June 2008 (revised)

Dr. Sharon M. Douglas
Department of Plant Pathology and Ecology
The Connecticut Agricultural Experiment Station
123 Huntington Street, P. O. Box 1106
New Haven, CT 06504

Phone: (203) 974-8601
Fax: (203) 974-8502
Email: Sharon.Douglas@ct.gov
Website: www.ct.gov/caes

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BLACK KNOT OF ORNAMENTAL PLUM AND CHERRY

Black knot is caused by the fungus *Apiosporina morbosa* (syn. = *Dibotryon morbosum*). This disease is common on many ornamental and flowering *Prunus* species in the landscape as well as on wild plums and cherries (especially wild black cherry, *Prunus serotina)* in woodlots and forests. Black knot was first reported as a destructive disease in Massachusetts in 1811. Although the disease can be found throughout North America, it is most common in the northeast.

Black knot is also a destructive disease of domestic plum and prune trees in home and commercial orchards. Apricots, peaches, and flowering almonds are occasionally damaged. The disease affects only woody tissues and can develop on twigs, branches, and scaffold limbs. Losses result from extensive dieback of girdled limbs and stunting of the growth beyond the visible knots. Infected trees may also produce few flowers or fruit. Trees can be severely weakened, disfigured, and in extreme cases, even killed as a result of infection.

SYMPTOMATOLOGY AND DISEASE CYCLE:

Symptoms of black knot are easily recognized during the winter, when they appear as distinctive, dark-brown to black charcoal-like swellings or growths (Figures 1 and 2). Knots can develop on twigs, branches, scaffold limbs, or trunks of trees (Figure 3). The conspicuous cylindrical or spindle-shaped knots do not appear until the second year of infection. They continue to enlarge from year to year and develop their characteristic rough appearance. Large, girdling knots result in dieback of branches and twigs. Girdling knots on the main trunk can kill trees.

Figure 1. Distinctive charcoal-like swelling of twig infected by the fungus causing black knot.

Although black knots are most outstanding on dormant trees, new infections can be detected early in the season and appear as soft, green swellings. As these age, they gradually turn hard and black.

Figure 2. Black knot girdling small twig.

Figure 3. Black knot cankers developing on large scaffold limbs.

The fungus overwinters in the knots on infected twigs and produces spores in spring. Humidity and temperature are the most important factors governing the spread of black knot disease. Release of spores depends on rainfall and temperature during early spring. These spores are the source of new infections. Newly emerging shoots are highly susceptible. They can be infected soon after budbreak and throughout the period of active shoot elongation. However, studies have shown that most infections probably occur just before bloom or after petal fall. Wet spring weather is favorable for disease since rain is important for discharging the spores from the knots. In addition, wind and rain help to spread the spores to the susceptible tissues. Spores of black knot are capable of penetrating non-wounded tissues, so they do not require wounds in order to infect.

Most infections occur in spring but symptoms are often not visible until fall when they appear as small, often inconspicuous swellings on the twigs. These knots gradually enlarge, mature, and take on their diagnostic rough, black appearance during the winter and the following spring. Small twigs usually die within a year of infection whereas larger branches may live for several years before becoming girdled and killed by the fungus.

DISEASE MANAGEMENT:

Black knot is managed using a combination of culture, pruning, sanitation, properly timed fungicide sprays, and resistant varieties. **Of these, pruning and sanitation are essential** to any control program--fungicide sprays are relatively ineffective unless old knots are pruned and removed from the vicinity of the tree. Infected tissues should be pruned *before budbreak* (and before the knots develop the white or pink appearance). Cuts should be made at least 6-8” below any visible swellings or knots.

Sanitation also includes scouting and removing and/or pruning of any wild plum or cherry trees found in woodlots within 600 ft. of the landscape tree in question. Since these wild trees are highly susceptible to black knot, they are important sources of fungal inoculum.

Cultural methods that contribute to managing this disease involve maintaining tree vigor. These include watering during periods of drought, fertilizing when necessary (as determined by a soil test), mulching, and avoiding all unnecessary stresses for the tree.

Resistance is another option for managing this disease. However, since this is a genetic trait, decisions about selecting resistant varieties need to be made at the time of purchase. There are unfortunately only a limited number of ornamental *Prunus* species with resistance to black knot. One example is Amur cherry or amur chokecherry (*Prunus maackii*) Goldrush® (*P. maackii* 'Jefree'), which appears to be resistant to black knot.

Edible or domestic plum varieties differ in their susceptibility to black knot. The cultivars Stanley, Damson, Bluefree, and Shropshire are considered to be highly susceptible; Fellenburg, Methley, Milton, Bradshaw, and Early Italian are moderately susceptible; Formosa, Shiro, and Santa Rose are slightly susceptible; and President is considered highly resistant. In general, Japanese varieties are less susceptible to black knot than most American varieties.

The final strategy for disease management involves the proper selection, timing, and application of fungicide sprays. Thorough coverage of all parts of the tree is necessary and the sprays should be applied until run-off. Among the fungicides registered for use on ornamental *Prunus* species in Connecticut are chlorothalonil and mancozeb + copper hydroxide. Applications are usually made when the tree is dormant (just before budbreak) and are continued until flowers have fallen (petal-fall). Organic options are limited, but a single lime-sulfur spray before budswell has been found to reduce black knot problems. The fungicide label should be consulted for information on specific tree hosts, dosage rates, and safety precautions.

If plum, cherry, or prune trees are being grown for edible fruit, please consult the fact sheet *Disease Control for Home Plum Orchards*. This guide contains information on fungicides registered for use on edible fruit.

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Dr. Sharon M. Douglas
Department of Plant Pathology and Ecology
The Connecticut Agricultural Experiment Station
123 Huntington Street, P. O. Box 1106
New Haven, CT 06504

Phone: (203) 974-8601
Fax: (203) 974-8502
Email: Sharon.Douglas@ct.gov
Website: www.ct.gov/caes

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BOXWOOD BLIGHT—A NEW DISEASE FOR CONNECTICUT AND THE U. S.

In October 2011, samples of boxwood with unusual symptoms were submitted to The Plant Disease Information Office of the Experiment Station for diagnosis. Symptoms included leaf spots and blights, rapid defoliation, distinctive black cankers on stems, and severe dieback (Figure 1).

Figure 1. Symptoms of boxwood blight on a boxwood from a landscape planting.

After extensive microscopic examination and a search of the literature, the disease was tentatively identified as boxwood blight, caused by the fungus *Cylindrocladium buxicola (*syn. *C. pseudonaviculatum)*. Since this fungus had not been reported in the U.S., samples of infected plants were sent to national mycologists at the United States Department of Agriculture-Animal Plant Health Inspection Service-Plant Protection and Quarantine (USDA-APHIS-PPQ) for identification. They confirmed the fungus as *C. pseudonaviculatum.*

HISTORY:

Boxwood blight, also called box blight and boxwood leaf drop, was first described in the United Kingdom (UK) in the mid-1990s, although the fungus was not formally identified at that time. However, in 2002, boxwood blight was found in New Zealand and the causal agent was described and formally named as a new species, *Cylindrocladium pseudonaviculatum.* Later that same year, the boxwood fungus from the UK was named *Cylindrocladium buxicola*. They are now known to be synonyms for the same fungus. Since those first reports, boxwood blight has been reported throughout Europe. This disease was included in the European Plant Protection Organization

(EPPO) Alert List from 2004-2008, but was removed, since no international action was requested during that period. Boxwood blight is widespread throughout the UK and, although not regulated, is considered a disease of great concern.

The geographic origin of the fungus is not known, nor is it known how the pathogen was introduced into the U.S. Boxwood blight has now been confirmed from 10 states in the U. S. (NC, CT, VA, RI, MD, MA, OR, NY, PA, and OH) and 2 provinces in Canada (BC, ON). At the time of this writing, boxwood blight has been found in some Connecticut landscapes, garden centers, and nurseries in Fairfield, Hartford, Middlesex, New London, and Windham counties.

HOSTS:

Boxwood blight has been reported to occur on all *Buxus* species to date, although some species and cultivars appear to be more susceptible than others. *Buxus sempervirens* 'Suffruticosa' (English boxwood) and *B. sempervirens* (American or common boxwood) appear to be highly susceptible. Other species of boxwood grown in Connecticut that have been found to be infected include many cultivars of *Buxus sinica* var. *insularis* (Korean boxwood), *Buxus microphylla* (little leaf boxwood), *Buxus microphylla* var. *japonica* (Japanese boxwood), and *Buxus sinica* var. *insularis* X *B. sempervirens* hybrids (Table 1). Published reports have not shown evidence of substantial resistance, since no boxwood species challenged with *C. pseudonaviculatum* have demonstrated any immunity. Experimental inoculations have revealed that *Sarcococca*, *Pachysandra terminalis*, and *P. procumbens* (recent research on pachysandra done at CAES), other members of the boxwood family (Buxaceae), are also susceptible. A recent find of a natural infection of an established planting of *P. terminalis* in the landscape by *C. pseudonaviculatum* provide additional evidence regarding a potential role for this host in disease spread. However, the complete host range of this pathogen is not known.

Table 1. Some species and cultivars of boxwood on which boxwood blight has been identified in Connecticut.

Host	Cultivar
Buxus microphylla var. *japonica*	'North Star' 'Green Beauty' 'Baby Gem'
Buxus sempervirens	'Suffruticosa' 'Elegantissima' 'Arctic Emerald' 'Jade Pillar' 'Graham Blandy'
Buxus sinica var. *insularis*	'Winter Gem' 'Winter Green'
Buxus sinica var. *insularis* X *B. sempervirens* hybrid	'Green Mountain' 'Green Gem' 'Green Velvet' 'Chicagoland' 'Green Ice' 'Big Leaf Gordo'

SYMPTOMS AND DISEASE CYCLE:

Cylindrocladium pseudonaviculatum infects all aboveground portions of boxwood, but does not appear to infect the roots (Figure 1). Initial symptoms appear as dark or light brown spots or lesions on the leaves (Figure 2). These lesions often have dark borders. Spots enlarge and then coalesce, often with a concentric pattern or a zonate appearance (Figure 3). Infected leaves then turn brown or straw colored, so infected plants look "blighted" (Figure 1). Defoliation often occurs very quickly after foliar symptoms first develop.

The fungus also infects the stems, which results in distinctive and diagnostic dark brown to black lesions, sometimes with an angular, diamond-like pattern (Figure 4). Many black lesions can be found along a stem, from the soil line to the shoot tips (Figure 5). Heavily infected plants drop most of their leaves. Although the plant attempts to regrow, repeated infection and defoliation can weaken the root system and lead to plant death, especially for young plants or new transplants.

Figure 2. Initial symptoms appear as dark or light brown spots on the leaves.

Boxwood blight can spread very rapidly under warm and humid conditions. For example, in 2011 we have seen several examples of established boxwood plantings in Connecticut landscapes that were apparently killed in one season following the introduction of infected plants—2011 had moderate to warm temperatures and was wet, including several violent rain events (Figures 6 and 7).

Boxwood blight can also be a very serious problem in commercial production settings, because the conditions are highly favorable for infection—many susceptible plants are grown in close proximity in a field or pot-to-pot in a hoop house, levels of humidity are often high, plants are often watered overhead, and leaf debris is abundant (Figures 8, 9, 10, 11, and 12).

Figure 3. Blighting of leaves. Lesions often have a concentric pattern or a "zonate" appearance (arrow).

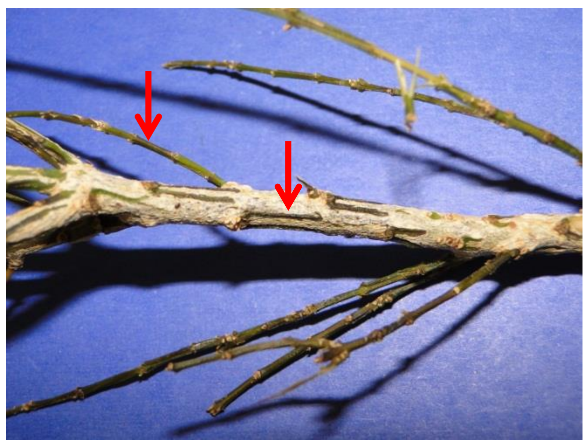

Figure 4. Diagnostic young, developing black cankers on stems (arrows).

The boxwood blight fungus readily forms fruiting structures on infected plants (Figure 13). These structures, called sporodochia, can be seen on the undersides of infected leaves (Figures 14 and 15) and on the black lesions on stems (Figure 16). Details are visible with a hand lens.

Figure 5. Dieback on stems girdled by coalesced, black cankers (arrow).

Sporodochia contain large numbers of sticky, cylindrical spores (conidia), which give the sporodochia an angular or crystalline appearance (Figure 17). Structures of the fungus called vesicles form in the sporodochia and protrude from the main fruiting body (Figures 17 and 18). Spores (conidia) are cylindrical and hyaline, and usually have one septation (Figure 19).

Boxwood blight spores are splash-dispersed and can be carried by wind or wind-driven rain over short distances. Longer distance spread is thought to occur through the activities of humans (e.g., contaminated boots, clothing, and equipment), animals, and birds, since the spores are sticky.

Infected plant material is the primary means for long-distance spread. The key factor for unintentional spread of this disease is movement of apparently "healthy" boxwood (infected, but asymptomatic or having very limited outward symptoms) or boxwood treated with fungicides that suppress, but do not kill or eradicate the fungus, to nurseries and landscapes. This method of disease transmission is often called the "Trojan horse" or "Typhoid Mary" syndrome.

Figure 6. Seven-year-old planting of boxwood infected with blight.

Figure 7. Established planting of boxwood with symptoms of boxwood blight.

The boxwood blight pathogen has a rapid disease cycle that can be completed in one week. It has a temperature range of 41-86 ºF. The optimum temperature for growth is 77 ºF. The fungus is sensitive to high temperatures and is killed after 7 days at 91 ºF. Infections can occur very quickly under warm (64-77 ºF), humid conditions.

The boxwood blight fungus does not require a wound to infect, since it can penetrate directly through the plant cuticle or can enter the leaf through stomata. High humidity levels or free water on plant tissues are necessary for successful infection.

Figure 8. Hoop house of symptomatic, off-colored boxwood in various stages of decline. Note leaf debris in walkway.

Figure 9. Boxwood blight symptoms in container-grown plants. Note extensive leaf debris in the pots and on landscape fabric.

Figure 10. Boxwood blight symptoms in a propagation flat.

Figure 11. Field-grown boxwood plants with symptoms of boxwood blight (note leaf debris, arrow).

Figure 12. Close-up of dieback and defoliation associated with black stem cankers.

Figure 13. Sporulation of the fungus on undersurfaces of symptomatic leaves (arrows).

Figure 14. Upper leaf surface with lesion (left) and sporulation on lower leaf surface (right).

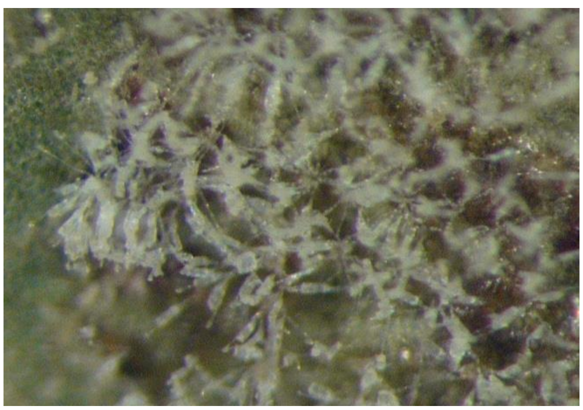

Figure 15. Sporulating colonies have an angular, “blocky” appearance.

Figure 16. Numerous fruiting bodies (sporodochia, arrow) emerging from black stem cankers.

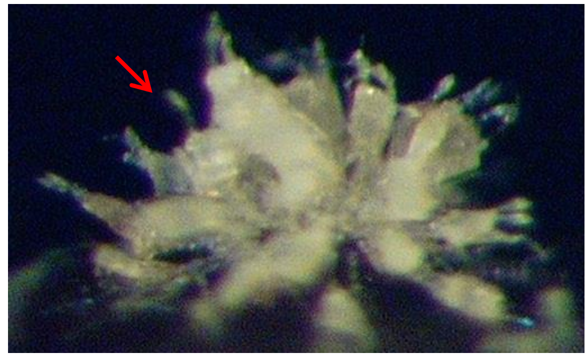

Figure 17. Angular appearance of spore clusters with many protruding vesicles (arrow).

Cylindrocladium pseudonaviculatum has been reported to survive as mycelium in cankers on infected plants and in leaf debris (fallen, infected leaves) (Figures 9 and 11). It has been reported to survive for at least 5 years on decomposing boxwood leaves. Resting structures called microsclerotia and chlamydospores have been reported to form in culture and have been observed to form in plant tissues in the U.S.

Figure 18. Photomicrograph of distinctive protruding vesicles (arrow) and cylindrical spores.

Figure 19. Photomicrograph of cylindrical, two-celled spores of the boxwood blight pathogen.

OTHER BOXWOOD DISEASES:

Boxwood in production and landscapes are susceptible to several diseases that can be confused with boxwood blight. These include Volutella blight, Macrophoma leaf spot, boxwood decline, and winter injury and sunscald. In addition, boxwood can be infected by more than one pathogen—we have commonly found boxwood blight along with Volutella canker and/or Macrophoma leaf spot.

Volutella blight (also called canker and leaf blight) is caused by the fungus *Volutella buxi (Pseudonectria rousseliana).* Symptoms are usually evident in spring, as individual shoots or entire plants exhibit poor growth. Leaves on affected shoots turn from green to a distinctive straw-tan color. Diagnostic, salmon-colored, somewhat waxy pustules of the fungus develop on the undersurfaces of infected leaves and stems (Figure 20). These are readily visible with a hand lens. The bark of infected shoots may be loose and peel to reveal gray or blackened, discolored wood underneath. Extensive dieback and leaf drop can occur, especially under wet conditions.

Macrophoma leaf spot is caused by the fungus *Macrophoma candolleri*. Leaves turn yellow or straw-colored and diagnostic fruiting structures of the fungus appear as small, black dots on the symptomatic leaves (Figure 21). This disease can result in extensive leaf drop.

Figure 20. Diagnostic, salmon-colored fruiting bodies of Volutella blight.

Figure 21. Diagnostic symptoms of Macrophoma leaf spot (left, upper leaf surface, right, lower leaf surface).

Boxwood decline is associated with root damage by root-knot nematodes *(Meloidogyne* and *Pratylenchus)*. Plants often undergo progressive decline over a period of several years. Symptoms include stunting, wilting, loss of vigor, and chlorosis. Some bronzing of internal foliage can occur. Depending upon the nematode, root symptoms include formation of swollen galls or lesions. Disease severity is influenced by nematode populations and other environmental factors that impair root function such as drought. Diagnosis requires soil samples from the vicinity of symptomatic plants to test for the presence of and populations of nematodes.

Winter injury or sunscald is associated with damage to the cambium and sapwood. Many species of boxwood are only marginally hardy in Connecticut. This type of injury results in dieback of leaves, twigs, and even entire plants. Leaves often develop a brown to reddish-brown, bronze color. Bark splitting and peeling on stems and branches is common and may also result in dieback.

MANAGEMENT STRATEGIES:

Whether in the nursery, garden center, or landscape, management of boxwood blight requires aggressive measures that include combined use of culture, scouting, sanitation, and when appropriate, fungicide sprays. Boxwood blight is generally considered a serious disease affecting the quality and aesthetics of plants, although in many cases it can lead to plant death. Since this disease has only recently been found in the U.S., we are not certain of any long-term implications on plant health, especially with regard to the role that repeated, defoliation might have on weakening plants and predisposing them to winter injury, insects, and opportunistic pathogens.

1. It is very important to start with pathogen-free material, by purchasing from reputable suppliers, nurseries, or garden centers. Plants and cuttings should be carefully inspected for symptoms.
2. Newly purchased plants or rooted cuttings should be isolated from existing boxwood plantings or production areas in nurseries for at least one month, but preferably, for several months.
3. Adequate spacing between plants can help to maximize air circulation and minimize conditions favorable for disease development.
4. Since water is important for the spread and development of boxwood blight, it is beneficial to avoid overhead watering. It also helps to avoid working with plants when they are wet, since this pathogen can be spread during these types of activities.
5. Sanitation, accomplished by raking and removing leaf debris, is critical for eliminating and reducing inoculum, since the fungus can survive in plant debris for up to five years. In commercial situations with field plantings, burning the plant debris with a propane torch might be an option.
6. Scout and inspect all boxwood plants daily or weekly. **As soon as boxwood blight symptoms are detected, immediately pull and remove whole plants and place them in a plastic bag to avoid carrying the infected material through the nursery or landscape. Infected plant material should NOT be composted.**
7. If you observe suspicious symptoms on boxwood, it is important to have the disease accurately identified by a specialist. An image gallery of boxwood blight can be found at: http://www.ct.gov/caes/pdio.
8. Planting less susceptible species of boxwood or alternatives to boxwood can reduce the potential for disease. Examples of alternative plants include some dwarf cultivars of *Ilex crenata*,

Pieris japonica, Rhododendron spp., and *Taxus baccata.*

9. The final strategy for managing boxwood blight involves selection, timing, and application of fungicide sprays. Reports on fungicide efficacy from countries that have been dealing with this disease for many years are not encouraging, since fungicides have not been found to be particularly effective. However, they can be used in conjunction with other management strategies previously outlined, especially when weather is favorable for disease. When there is a risk of boxwood blight occurring, fungicide applications need to be used on a regular preventive schedule. Because of the tight nature of the boxwood canopy, thorough coverage with fungicides is difficult. However, all parts of the plant need to be covered so any sprays should be applied until run-off. Because this is a new disease for the U.S., boxwood blight will not be on any fungicide labels. However, fungicide labels of products that can be used on boxwood will contain information on dosage rates, reentry intervals (REI), and safety precautions. FUNGICIDES ARE NOT CURATIVE.
    a. For Connecticut homeowners, the fungicides chlorothalonil and mancozeb are registered for use. Since these are protectant materials, they should be applied before symptoms are observed and repeated as necessary when conditions are favorable for disease development and spread.
    b. Commercial nursery growers should follow a preventative fungicide program that includes different products with different modes of action (FRAC groups). Among the fungicides registered for use are azoxystrobin, boscalid + pyraclostrobin, chlorothalonil, fludioxonil, kresoim-methyl, and mancozeb. These products differ significantly in their mode of action (e.g., some are more effective in inhibiting spore germination; others are more effective at inhibiting mycelial growth).
10. Please contact the Experiment Station for the most current information on control.

For answers to questions or assistance with diagnosing boxwood blight, please contact the Experiment Station's
Plant Disease Information Office
Phone: 203.974.8601
Statewide Toll-Free: 877.855.2237
Website: www.ct.gov/caes/pdio

All photos are from CAES and include contributions courtesy of S. M. Douglas, M. K. Inman, V. L. Smith, and P. Trenchard.

20 July 2012 (Revised)

CAES

The Connecticut Agricultural Experiment Station

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FACT SHEET

BRIEF SYNOPSIS OF TREE DISEASES BY CATEGORY

Dr. Sharon M. Douglas
Department of Plant Pathology and Ecology
The Connecticut Agricultural Experiment Station

A. FOLIAGE DISEASES

These comprise the most common of all plant diseases that we encounter in the landscape. In most cases, they are considered to be **more aesthetic than life- threatening** problems although they can result in significant premature leaf drop.

Symptoms:

- Usually considered cosmetic or aesthetic rather than life-threatening;
- Infection is usually limited to the foliage;
- Premature leaf drop or defoliation can occur;
- Rarely results in tree death.

Subdivided into several types: Leaf Spots, Anthracnoses, Needlecasts, Powdery Mildews, and Rusts.

1. Leaf Spots-

These are the most prevalent plant diseases

Symptoms:

- Characterized as dead spots scattered over the surface of the leaf;
- The size, color, and shape can vary with the individual host and pathogen but they usually have definite margins;
- Can result in substantial premature defoliation.

Examples:

Apple Scab
Hawthorn Leaf Blight
Horsechestnut Leaf Blotch
Maple Leaf Spot
Oak Leaf Blister
Tar Spot

2. Anthracnoses-

Symptoms:

- Characterized as necrotic or dead areas on the leaves;
- Often V-shaped and defined by the venation pattern of the leaf;
- Can also appear as blotchy, dead areas or as discrete leaf spots;
- Severe infections result in small cankers causing twig and branch dieback;
- Significant defoliation can occur;
- Most serious during wet, cool springs.

Examples:

Anthracnoses (of many hosts)
Dogwood Anthracnose

3. Needlecasts-

Symptoms:

- Characterized by premature needle drop, browning, chlorosis;
- Can also be associated with branch and twig dieback;
- Defoliation or needle drop can be significant.

Examples:

Lophodermium Needlecast of Pine
Rhizosphaera Needlecast of Spruce

4. Powdery Mildews-

Symptoms:

- Characterized as gray to white, powdery growth, usually first evident on the upper surface of the leaf;
- Symptoms can vary with each host and can result in minimal to extensive premature browning and defoliation;

- Usually develop mid to late in the growing season.

Examples:

Powdery Mildews (of many hosts)

5. <u>Rusts-</u>

Symptoms:

- Characterized as brightly colored, raised blisters or pustules that develop on leaves or needles;
- These blisters break open to reveal colorful spores; many are orange to rusty brown, for that these diseases are named;
- Can result in premature defoliation;
- On evergreens, symptoms can also develop as galls or swellings on twigs and branches.

Examples:

Cedar-Apple Rust
Cedar-Hawthorn Rust
Spruce Needle Rusts

MANAGEMENT STRATEGIES FOR FOLIAGE DISEASES:

a. maintain tree vigor by following sound cultural practices;
b. prune out dead branches or twigs in spring;
c. rake and remove fallen leaves (or needles) in autumn;
d. use resistant species or cultivars when available;
e. avoid close spacing to promote good air circulation;
f. avoid overhead irrigation;
g. most foliage diseases are generally not serious enough to warrant chemical control;
    - however, there are exceptions with regard to the value of the tree, the specific host and type of foliar disease involved, the nature of the host-associated damage, and the timing of defoliation;
    - most available pesticides are protectants and must be applied to developing foliage **before** symptoms appear;
    - the number of sprays required for control will vary with the fungicide and weather conditions.

B. BLIGHTS AND DIEBACKS

These types of diseases are generally considered much more serious than foliage diseases since they can result in tree death.

Symptoms:

- Characterized as sudden and conspicuous damage to leaves and growing tips;
- Blackening or wilting of growing tips, death of shoots and tips;
- Often more severe during wet weather or on trees that have been stressed by other factors;
- Can result in tree death.

Examples:

Fire Blight
Diplodia Blight

Management Strategies:

a. avoid tree stress and maintain good vigor by following sound cultural practices;
b. protect trees from winter injury;
c. use resistant species or cultivars when available;
d. prune, remove, and destroy diseased portions of trees, especially spent flowers and leaf debris;
e. pesticides are helpful in some host-pathogen combinations; many are protectants and need to be applied before symptoms appear; the effectiveness and number of sprays required for control will vary with weather conditions.

C. BRANCH AND STEM CANKERS

These types of diseases are generally considered to be serious since they can result in tree death.

- Limited information on how pathogens actually invade, kill, and colonize host tissues;

- Believed that most pathogens do not actively invade host tissues but wait for an "opportunity" to invade through wounds or natural openings;
- Can result in stem, branch, and tree death.

Symptoms:

- Cankers may appear as definite areas that vary in color from surrounding healthy tissues;
- They can be necrotic, sunken lesions that appear tan to dark brown or can be swollen areas; these can develop along twigs, branches, and main stems or trunks;
- When cankers girdle the stem or branch, leaves wilt, drop, and the distal portion of the stem or branch dies;
- Can result in tree death.

Examples:

Beech Bark Disease
Black Knot
Bleeding Canker
Botryosphaeria Canker
Chestnut Blight
Cytospora Canker
Hypoxylon Canker
Nectria Canker
White Pine Blister Rust

Management Strategies:

a. prune and remove affected plant parts (e.g., limbs, stems) or entire trees;
b. maintain tree vigor by following sound cultural practices;
c. avoid tree stress by proper site selection;
d. pesticides are helpful with *some* host-pathogen combinations, but need to be applied *before* symptoms appear.

D. VASCULAR DISEASES (WILTS)

These types of diseases are serious and usually result in tree death.

Symptoms:

- Characterized by loss of rigidity, wilting, yellowing of foliage, drooping of branches;
- Often followed by premature defoliation;
- Gradual dieback may be evident;
- "Flagging" may occur when one limb becomes symptomatic at a time;
- Infected trees will occasionally produce a heavy crop of seed and have leaves that are smaller than normal;
- Infected trees *may* develop characteristic brown, greenish, or yellow streaks in the vascular tissues;
- **Once infected, trees are rarely "cured," since the pathogen grows systemically in the tree, in the vascular system (xylem or phloem);**
- Usually results in tree death.

Examples:

Ash Yellows
Dutch Elm Disease
Elm Yellows
Verticillium Wilt

Management Strategies:

a. prune and remove affected branches or limbs as soon as symptoms are evident;
b. plant resistant species or varieties where possible;
c. maintain overall tree health by following sound cultural practices;
d. avoid tree stress by appropriate site selection;
e. use pesticides when appropriate (injections?).

E. ROOT DISEASES

These types of diseases are serious and usually result in tree death.

Symptoms:

- Root diseases are very difficult to diagnose since the aboveground symptoms are nonspecific; the real problem is underground in the roots!
- Leaves turn yellow, wilt, and droop;
- Twig, stem, and branch dieback;
- General decline, reduced or stunted growth;
- Results in root and tree death.

Examples:

Armillaria Root Rot

Phytophthora Root Rot

Management Strategies:

a. protect trees from drought or flooding and avoid wet areas;
b. maintain tree vigor by following sound cultural practices;
c. remove and destroy affected trees or plants; stump removal and removal of woody roots greater than ½ inch in diameter are often prudent and necessary;
d. select resistant species or varieties when available;
e. pesticides are helpful with *some* host-pathogen combinations but are not curative and need to be applied *before* infection occurs.

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Dr. Sharon M. Douglas
The Connecticut Agricultural Experiment Station
Department of Plant Pathology and Ecology
123 Huntington Street, P.O. Box 1106
New Haven, CT, 06504

E-mail: Sharon.Douglas@ct.gov
Phone: (203) 974-8496
(203) 974-8601
Website: www.ct.gov/caes

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FACT SHEET

BROWNING, DIEBACK, AND DECLINE OF EASTERN RED CEDAR

Dr. Sharon M. Douglas
Department of Plant Pathology and Ecology
The Connecticut Agricultural Experiment Station

First observed in 2004, Eastern red cedar (*Juniperus virginiana*) in many areas of the state have exhibited a recurring range of symptoms, including needle browning and premature drop, branch and twig death, and general tree decline. Symptoms generally develop in April and continue into May and June. Many trees appear to recover as new growth emerges by mid-summer, whereas others trees continue to decline. In some cases, trees have ongoing, recurring symptoms for several consecutive years. No patterns have emerged with regard to location or tree age.

SYMPTOMATOLOGY AND POSSIBLE CAUSES

Although this native species is usually considered relatively trouble-free in Connecticut, dramatic and conspicuous damage has been a recurring problem, occasionally visible on trees in all age and size classes, care regimes, and locations, including natural stands and managed landscapes. Severely affected trees appear distinctly off-color from a distance (Figure 1). Upon close inspection, a range of symptoms is observed, which include needle browning and drop, primarily of older, inner needles (Figure 2), tip and twig dieback, and branch death. In extreme cases, entire trees turn brown. These symptoms are not distinctive or diagnostic. We have had reports of trees without a history of prior symptoms or problems suddenly start to develop extensive symptoms in spring. Trees in compromised sites (e.g., exposed to road salt, increasing levels of shade) have also exhibited a similar range of symptoms.

Figure 1. Affected red cedar tree distinctly off-colored from a distance in early summer.

In some cases, new growth was observed at the bases of small, dead twigs. This suggests that cambial tissues were still viable on some of the larger-diameter wood, despite extensive needle browning, drying, and premature drop.

Figure 2. Close-up of needle browning in spring.

After several years of examining samples, no primary pathogens, insects, or mites appear to be directly associated with the symptoms. However, efforts to further characterize and identify the cause(s) are still ongoing. The occurrence of symptoms in other localized areas of New England provides further evidence for an environmental phenomenon or series of events. One possible scenario to explain the development of the symptoms includes damage from the combination of quirky weather conditions of the past few years, including periods of very dry or very wet conditions and extremes of winter temperatures. Although for most years, some level of winter damage can be observed on red cedar in spring, the proposed scenario suggests the cumulative effects of these weather factors can result in greater than usual damage. Winter injury results from many environmental factors, which often have little in common other than they occur during the winter. Examples of these diverse factors include cool summers followed by warm autumns and sudden drops in temperature, dramatic temperature fluctuations, freeze-thaw cycles, unusually warm, midwinter temperatures, extended periods of extreme or abnormally cold temperatures, and drying winds. Winter desiccation is common on red cedar and results from factors that create a water deficit in the tree. Injury occurs when water evaporates from needles on windy or warm sunny days during the winter or early spring. Drying occurs because this water is not replaced since the roots cannot take up enough water from cold or frozen soil. Lack of water, or drought, normally doesn't cause problems for red cedar since they are considered to be drought-tolerant. However, extended dry periods for several consecutive years can result in root damage. This damage is often observed in groups of trees rather than in isolated individuals. Excess water can also create periods of waterlogged soils and short-term anaerobic conditions. Red cedar has low anaerobic tolerance. Fact sheets with more detailed information on drought, excess water, and winter injury are available on the Experiment Station website (www.ct.gov/caes/pdio).

The damage to the red cedars that we've observed for the past several years is significant, but also serves to predispose and weaken affected trees. This makes them more vulnerable to secondary or opportunistic pests. Among these less serious or secondary problems are tip and twig blights caused by *Phomopsis* and *Kabatina* and cankers and diebacks caused by *Botryosphaeria*. In addition, stressed or weakened trees are more attractive to a number of arthropod pests, including the smaller Japanese cedar longhorn beetle, borer, and other beetle infestations. Infestations of the longhorn beetle can be recognized as serpentine tunnels on the main trunk or on larger-diameter branches.

In some years, many trees appeared to recover, as evidenced by new growth. However, other trees continued to decline and had substantial and permanent damage, often leading to tree death.

STRATEGIES FOR MANAGEMENT:

Although the weather can't be controlled and there are no obvious "cures" once the damage is done, there are steps that can minimize the impact of this problem. These include:

- Use sound cultural practices to promote tree vigor;
- Have sufficient moisture in the root zone before the soil freezes-- this can be accomplished by giving the trees a deep watering before the ground freezes in the fall; mulching also helps to increase moisture retention in the winter;
- Avoid late summer and early fall fertilization-- this stimulates and encourages growth late in the season which may not harden-off properly for the winter;
- Prune and remove any dead twigs or branches;
- Scout for secondary invaders and/or opportunistic pests.

Since we are continuing to monitor this new problem, you can contact the Experiment Station for the most current information.

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Dr. Sharon M. Douglas
The Connecticut Agricultural Experiment Station
Department of Plant Pathology and Ecology
123 Huntington Street, P.O. Box 1106
New Haven, CT, 06504

E-mail: Sharon.Douglas@ct.gov
Phone: (203) 974-8496
(203) 974-8601
Website: www.ct.gov/caes

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The Connecticut Agricultural Experiment Station
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Dr. Sharon M. Douglas
Department of Plant Pathology and Ecology
The Connecticut Agricultural Experiment Station
123 Huntington Street, P. O. Box 1106
New Haven, CT 06504

Phone: (203) 974-8601
Fax: (203) 974-8502
Email: Sharon.Douglas@ct.gov
Website: www.ct.gov/caes

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CEDAR-APPLE RUST

Cedar-apple rust is a distinctive disease that is indigenous and widespread throughout the Northeast in areas where apples and crabapples grow in close proximity to members of the juniper family.

SYMPTOMATOLOGY AND DISEASE CYCLE:

Cedar-apple rust, caused by the fungus *Gymnosporangium juniperi-virginianae*, is a heteroecious rust that requires two different hosts to complete its two-year life cycle. The primary hosts are species of *Malus*--apple (*M. domestica*) and crabapple (*M. sylvestris* and other *Malus* species). The alternate hosts are members of the genus *Juniperus*, which includes the native Eastern red cedar (*J. virginiana*) as well as many ornamental junipers. The fungus must spend part of its life cycle on both hosts. The cedar-apple rust fungus is a *Gymnosporangium* rust and has a similar life cycle and is closely related to several other *Gymnosporangium* rusts, including cedar-hawthorn rust and cedar-quince rust.

The symptoms of cedar-apple rust disease on Eastern red cedar and other junipers are inconspicuous during the winter and appear as brown, kidney-shaped galls that vary in size from ¼-2 inches in diameter (Figure 1). As the temperatures begin to rise in the spring, the fungus begins to grow in the galls (Figure 2).

Figure 1. Dormant cedar-apple rust gall overwintering on Eastern red cedar.

Figure 2. Gall with telial horns beginning to emerge in early to mid-spring.

Figure 3. Spectacular, gelatinous telial horns develop from galls after rain.

Figure 4. Eastern red cedar "decorated" with many galls in spring.

After periods of cool, rainy weather, the spectacular and distinctive bright orange, gelatinous spore horns develop and protrude from the surface of these galls (Figure 3). They can be up to four inches long. Heavily infected junipers appear to be "decorated" with many colorful galls (Figure 4).

Spores called teliospores are produced in these gelatinous spore horns or tendrils. As the teliospores germinate, they produce another type of tiny spore, called a basidiospore. These spores can only infect apple and crabapple. Basidiospores are released and carried by wind and driving rain to newly emerging leaves of the alternate hosts, apple and crabapple. As many as 7.5 million basidiospores may be produced in a single gall. These spores have been shown to be carried as far as six miles. Once the spores land on the emerging apple or crabapple leaves, they germinate and infect the leaves when they are wet.

Symptoms of infection on the apple and crabapple hosts are also quite colorful. Lesions first appear in early June as greenish-yellow spots that increase in size. They develop into characteristically brightly colored spots--the color can vary from yellowish-orange to red, depending upon the apple or crabapple cultivar (Figure 5 and 6). Symptoms are visible on both the upper and lower leaf surfaces (Figure 7).

Figure 5. Symptoms on red-pigmented crabapple (upper leaf surface).

Symptoms rarely develop on fruit and twigs. By mid-summer, minute "spore cups" called aecia develop at the edge of the lesions on the lower leaf surface.

Figure 6. Diagnostic symptoms of cedar-apple rust on leaves (upper leaf surface).

Figure 7. Symptoms on lower surfaces of crabapple leaves. Aecia are visible in these lesions.

The spores produced in these cups are called aeciospores. These spores are released from mid-summer into autumn. Aeciospores can only infect junipers and cannot infect other apples or crabapples. They are carried by wind and rain back to the juniper and red cedar hosts where they initiate another cycle of disease. When these spores land they germinate and stimulate the formation of galls. Galls are initially green to greenish-brown and gradually darken to brown as they age. It takes from 19-22 months to complete one life cycle of this fungus.

DISEASE MANAGEMENT:

Cedar-apple rust is not considered a life-threatening disease to either type of host so control measures are usually not necessary in most cases. However, if significant defoliation and/or fruit loss is experienced on apple or crabapple hosts, control measures may be necessary. This disease can be effectively managed through the combined use of culture, sanitation, resistance, and fungicide sprays. Cultural methods involve removal of either host within ½-1 mile from the other, although in most cases this is not feasible.

Sanitation involves pruning and removing galls from the red cedar and juniper hosts during the dormant season. Once again, this is practical in limited situations where only a few trees are involved and only a few galls are present.

Selection and planting of resistant cultivars or varieties is the most effective means of control since this effectively reduces or eliminates the occurrence of the disease. Examples of resistant apple cultivars include Delicious, Empire, Jonamac, McIntosh, and Paulared. Resistant crabapples include Ellwangerina, Henry Kohankie, Ormiston Roy, and Red Baron. Resistant junipers are: *Juniperus chinensis* var. *sargentii*, *J. communis* cv. Aureospica, and *J. virginiana* cv. Tripartita.

The final strategy for disease control involves the proper selection, timing, and application of fungicide sprays. Thorough coverage of all parts of the tree is necessary and the sprays should be applied until run-off. The fungicide label will contain information on plant hosts and diseases, dosage rates, preharvest harvest interval (PHI), and safety precautions. Among the fungicides registered for use in Connecticut are chlorothalonil, mancozeb, triadimefon, propiconazole, and myclobutanil are registered for use and should be applied as necessary. An organic management option is sulfur. If harvesting fruit for consumption, please consult the fact sheet *Disease Control for Home Apple Orchards*. This guide contains information on fungicides registered for use on edible fruit.

Use of fungicides to protect *Juniperus* species has yielded disappointing results due to the difficulty in determining the timing of the applications since this mid-summer through fall infection period remains poorly understood. One of the only fungicides registered for use on junipers in the landscape is triadimefon.

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Dr. Sharon M. Douglas
Department of Plant Pathology and Ecology
The Connecticut Agricultural Experiment Station
123 Huntington Street, P. O. Box 1106
New Haven, CT 06504

Phone: (203) 974-8601
Fax: (203) 974-8502
Email: Sharon.Douglas@ct.gov
Website: www.ct.gov/caes

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COMMON DISEASES OF CRABAPPLE

There are several diseases that commonly occur on ornamental crabapples in landscapes throughout the state every year. These fungal diseases are scab and two Gymnosporangium rusts (cedar-apple rust and cedar-hawthorn rust). A bacterial disease called fire blight is considered to be an occasional problem. However, when this disease occurs, it can be very damaging. The occurrence and severity of these diseases are influenced by many factors, including the level of infection and amount of overwintering inoculum from the previous year, the weather at the time of leaf emergence, cultural practices, and the species or cultivar of crabapple that is planted.

I. SCAB:

Causal Agent: *Venturia inaequalis* (fungus)

Symptoms and Disease Development:

Scab, sometimes referred to as "apple scab," is the most noteworthy and common disease of crabapple in Connecticut. It is usually most severe after cool, wet spring weather. Leaf symptoms are first visible in May or early June and appear as pale green blotches. These develop into circular, olive-black, velvety lesions with feathery margins that are diagnostic for this disease (Figure 1). These lesions are often found along the mid-

Figure 1. Olive-black, velvety scab lesions with feathery margins.

Figure 2. Scab lesions concentrated along the midvein of a leaf.

vein (Figure 2) where the leaf surfaces stay wet for longer periods of time. Infected leaves usually turn yellow or chlorotic, even when they only have a few spots. As the leaves yellow, they often drop prematurely. Heavy leaf infections can result in significant defoliation of highly susceptible crabapples by July. When the trees are otherwise healthy and vigorous, premature defoliation is more of a cosmetic or aesthetic problem, which rarely has long-term health implications.

Symptoms also develop on fruit and young fruit stems. Lesions on fruit appear similar to those on the leaves but they become corky and crack as the fruit enlarge. Infections on young fruit can cause fruit deformity as the fruit expands.

The fungus overwinters on dead, fallen leaves. These leaves serve as a critical source of primary inoculum (fungal spores responsible for primary infections) available to infect newly emerging leaves and young fruit during periods of rain or overhead irrigation in spring. If scab symptoms develop on leaves or fruit by late spring from these primary infections, a secondary cycle of infection is initiated. This secondary or summer cycle is caused by a second type of spore (different from those responsible for spring infections). These spores initiate new infections after they land on leaves and developing fruit during periods of wind-driven rain or irrigation during the summer. Summer infections of scab can result in dramatic increases in both the severity and prevalence of disease on individual trees.

Management of Scab:

<u>Cultural Practices</u>—it is helpful to keep trees vigorous by following sound cultural practices, controlling insect infestations, and watering during periods of drought. Pruning crabapples in late winter to "open" the canopy of the tree helps to reduce disease by increasing air circulation, which results in faster drying of the tissues. It also allows for better penetration of spray materials if they are part of the management program.

<u>Sanitation</u>—a good sanitation program in which diseased leaves and fruit are removed from the vicinity of the tree will also help to eliminate sources of primary inoculum in the spring.

<u>Resistance</u>—Scab is most effectively managed by planting resistant varieties. A partial list of resistant crabapples that are hardy in Connecticut includes Adams, Baskatong, Brandywine, Callaway, David, Dolgo, Donald Wyman, *Malus floribunda*, Henry Kohankie, Henningi, Jewelberry, Ormiston Roy, Professor Sprenger, *Malus seiboldi* var. *zumi* cultivars Calocarpa, Silver Moon, Sugartyme, *Malus tschonoski*, Weeping Candy Apple, White Angel, and White Cascade.

<u>Fungicides</u>—when heavy defoliation is frequent, fungicide sprays are often helpful. Among the fungicides registered for use in Connecticut are chlorothalonil, copper sulphate pentahydrate; mancozeb, myclobutanil, propiconazole, and thiophanate-methyl. For organic management, acceptable formulations of copper, neem oil, potassium bicarbonate, and sulfur can be used to reduce infections. Applications can be made at budbreak and repeated at label intervals until mid-June. More frequent and prolonged sprays may be necessary in wet weather.

II. GYMNOSPORANGIUM RUSTS

There are over 40 species of Gymnosporangium rusts in North America but two species are significant on crabapple throughout Connecticut and New England. These are cedar-apple rust and cedar-hawthorn rust. These fungi are closely related and are heteroecious, meaning that they require two different hosts to complete their life cycles. The primary hosts are members of the Rose family (Rosaceae), crabapples in this case. The alternate hosts are evergreens in the genus *Juniperus,* which includes the native Eastern red cedar (*J.*

virginiana) as well as many ornamental junipers (e.g., Chinese, low, and creeping junipers). These diseases are most problematic when both hosts grow in close proximity. Refer to the fact sheet "Gymnosporangium Rusts" by S. M. Douglas for more detailed information and photos of these diseases.

Figure 3. Symptoms of cedar-apple rust on red-pigmented crabapple (upper leaf surface).

A. CEDAR-APPLE RUST

Causal Agent: *Gymnosporangium juniperi-virginianae* (fungus)

Symptoms and Disease Development: Infections result in brilliant yellow-orange spots or lesions on crabapple leaves and occasional lesions on the calyx end of the fruit. Symptoms first appear in early June as greenish-yellow spots that gradually increase in size. They eventually develop into brightly colored spots—the color varying from yellowish-orange to red, depending on the variety (Figures 3 and 4). Fungal fruiting structures called aecia develop within the lesions and are visible on the undersurfaces of the leaves. These are typically short, cup-like protrusions (~$^1/_8$ inch long) (Figure 5). Spores are produced in these structures during the summer that can only infect juniper. They are carried by wind to junipers where they initiate new infections.

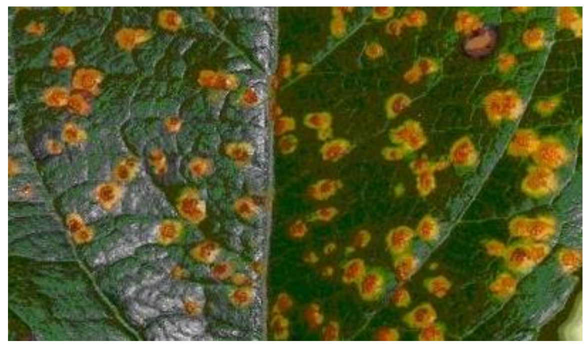

Figure 4. Characteristic yellow-orange lesions on the upper surface of a crabapple leaf.

Heavy foliar infections of crabapple can result in leaf yellowing and substantial premature defoliation.

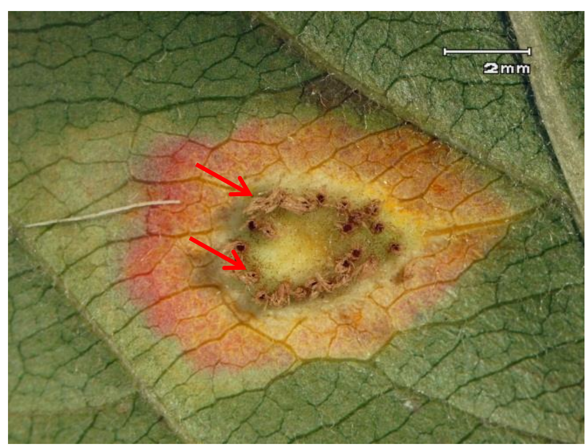

Figure 5. Aecia (arrows) are cup-like protrusions visible in the rust lesion on the lower leaf surface.

On juniper hosts, infections result in brown to reddish-brown galls, ¼-2 inches in diameter (Figure 6). These galls are generally inconspicuous during the winter. However, during rainy periods in the spring, distinctive bright orange, gelatinous spore-horns protrude from the surface of these galls (Figure 7). The spores are blown by the wind to crabapple trees where they infect and produce characteristic lesions on newly developing crabapple leaves.

Figure 6. Dormant cedar-apple rust gall overwintering on Eastern red cedar.

Figure 7. Spectacular, gelatinous telial horns develop from galls after rain.

B. CEDAR-HAWTHORN RUST-
Causal Agent: *Gymnosporangium globosum* (fungus)
Symptoms and Disease Development:
Symptoms usually develop on leaves but cedar-hawthorn infections can also result in symptoms on fruit, petioles, and twigs. On leaves, characteristically brightly colored lesions develop in June and July (Figure 8). Cedar-hawthorn rust can be distinguished from cedar-apple rust by several attributes of the fungal fruiting structures (aecia) on the undersurface of the leaves of crabapple. For example, the aecia of cedar-hawthorn rust are substantially longer than those of cedar-apple rust and appear as finger-like

Figure 8. Brightly colored cedar-hawthorn rust lesions on crabapple.

Figure 9. Long, finger-like aecia protrude from the lower surface of a cedar-hawthorn rust lesion.

projections (Figure 9). Heavy foliar infections can result in yellowing and premature defoliation.

Symptoms of cedar-hawthorn rust on Eastern red cedar and other junipers are usually inconspicuous, especially during winter. They are small, brown galls from $^{1}/_{8}$-$^{9}/_{16}$ inch in diameter (Figure 10), and can appear flattened on the side attached to the twig. These galls are much smaller than those associated with cedar-apple rust. In spring, brightly colored telial horns protrude from the galls, but they are typically much smaller and less spectacular than those produced in cedar-apple rust (Figure 11).

Figure 10. Dormant cedar-hawthorn gall (arrow) on juniper.

Figure 11. Telial horns protruding from cedar-hawthorn galls in spring.

Management of Gymnosporangium Rusts:
Cultural Practices—these include removal of either host within ½-1 mile from the other, although in most cases this is not a feasible option. Crabapple trees should also be kept as vigorous as possible by following sound cultural practices to maintain tree vigor, controlling insect infestations, and watering during periods of drought.
Sanitation—Galls can also be pruned and removed from juniper branches during dormancy, although this is usually not practical.
Resistance—Selection and planting of resistant varieties is the most important and effective method of managing rust diseases. Examples of rust-resistant crabapple varieties include Adams, Dolgo, Donald Wyman, Firecracker, Ellwangerina, Henry Kohankie, Ormiston Roy, and Prairifire.
Fungicides—in situations where rust diseases rarely occur or very limited infections occur, no control is usually necessary. However, where disease is frequent and severe, fungicide sprays can be applied to the crabapple hosts. Among the fungicides registered for use in Connecticut are chlorothalonil, mancozeb, triadimefon, myclobutanil, propiconazole, and thiophanate-methyl. For organic management, acceptable formulations of sulfur can be used to reduce infections. Applications can be made at budbreak and repeated at label intervals as necessary. More frequent sprays may be necessary in wet weather. Fungicide control for juniper hosts is usually not practical since it usually requires a season-long spray program.

III. FIRE BLIGHT-
Causal Agent: *Erwinia amylovora* (bacterium)
Symptoms and Disease Development:
Fire blight is the most devastating disease of crabapple in the landscape. Fortunately, this disease is only an occasional problem and when it does occur, it is often isolated to specific geographical locations. However, when infection does occur, the disease can develop quite rapidly and can destroy individual trees in a single season.

Infected blossoms and leaves suddenly wilt and turn dark brown to black, shrivel, and die, but usually remain attached to the plant (Figure 12). Leaves show a blackening of the petiole and adjacent tissue can be seen before the whole leaf dies. Infected fruit appear leathery and often ooze with bacteria. Cankers on limbs are characteristically shrunken and dark brown to purplish in color. Dark streaking in the wood often extends several inches beyond any surface discoloration. A diagnostic symptom of fire blight is the bending of the "blighted" terminal, which resembles a shepherd's crook.

Figure 12. Blackened leaves remain attached to infected shoots.

The bacteria survive the winter in old cankers on infected crabapples and other plant hosts and in healthy buds. As weather becomes favorable for growth in spring, the bacteria begin to rapidly multiply and can be seen oozing out of tissues. This creamy bacterial ooze is attractive to insects, which pick up the bacteria and carry them to open flower buds where infection occurs. Infections can also occur through natural openings in leaves (stomata), branches (lenticels), pruning wounds, insect feeding and ovipositing, and hail. The bacteria are also carried by wind and rain to open blossoms. Infected tissues are characterized by their blackened, "burned" appearance, hence the name "fire blight."

Management of Fire Blight:

<u>Cultural Practices</u>—the effects of this disease can also be minimized by maintaining overall tree health following proper cultural practices that avoid excessive vigor. It is especially important to avoid heavy applications of nitrogen in spring.

<u>Sanitation</u>—this is a **very** important aspect of control. Any cankered or infected branches or twigs should be cut back to healthy wood during the dormant season. All pruning cuts should be made at least 8-12 inches below visible symptoms. All tools should be disinfested with 10% household bleach (1 part bleach: 9 parts water) or 70% alcohol. Prunings should be removed from the vicinity of the tree.

<u>Resistance</u>—the most effective method for managing this disease is to select and plant crabapple varieties that are resistant to fire blight. These include: Adams, Adirondack, Autumn Glory, Camelot, David, Lancelot, Indian Summer, Jewelberry, Liset, Profusion, Prairifire, Tina, and White Angel.

<u>Chemical Control</u>—this is generally not suggested for landscape crabapples. However, dormant copper sprays applied to the bark in early spring before budbreak have been shown to reduce the growth of bacteria on bark surfaces.

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Dr. Sharon M. Douglas
Department of Plant Pathology and Ecology
The Connecticut Agricultural Experiment Station
123 Huntington Street, P. O. Box 1106
New Haven, CT 06504

Phone: (203) 974-8601
Fax: (203) 974-8502
Email: Sharon.Douglas@ct.gov
Website: www.ct.gov/caes

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COMMON DISEASES OF MAPLE

There are a number of diseases that occur on maples throughout Connecticut every year although the severity and distribution of these problems vary with each season, each site, and each species. Diseases occur on maples in the landscape as well as those growing in natural woodlots and forests. Anthracnose, fungal leaf spots (including tar spot), powdery mildew, and Verticillium wilt are diseases that are usually encountered every year whereas leaf scorch is an occasional problem. The species of maple that we most frequently encounter in the Plant Disease Information Office are: *Acer palmatum* (Japanese maple), *A. platanoides* (Norway maple), *A. pseudoplatanus* (sycamore maple), *A. rubrum* (red or swamp maple), *A. saccharinum* (silver maple), and *A. saccharum* (sugar maple). The degree to which each species is affected by disease can be quite variable and is influenced by genetic factors, microclimate, and predisposition by other stresses (e.g., drought, excess water, winter injury).

I. ANTHRACNOSE:

Causal Agents: Several genera of fungi (e.g., *Aureobasidium, Discula, Kabatiella*).
Symptoms: The symptoms associated with anthracnose diseases vary with the species of maple and the fungus. Symptoms are often apparent from late spring to early summer but additional cycles of disease can result in damage, which is visible later in the growing season. The range of symptoms includes leaf spots, blighted leaves and young shoots, cankers, and dieback of young twigs and branches. The most common symptoms are large, irregular dead areas on the leaf that are often V-shaped or delineated by the veins (Figures 1 and 2).

Figure 1. Typical anthracnose lesions delineated by the veination pattern of the leaves.

These areas can be tan and paper-thin. When infection is severe, the fungus enters the petioles and causes entire leaves to appear blighted, browned, and shriveled.

These symptoms are often confused with drought and heat stress since they are very similar. Significant leaf drop and premature defoliation can occur. Samaras can also develop necrotic or dead spots and drop prematurely.

Figure 2. Close-up of anthracnose lesion.

Management: Refer to management strategies for foliar diseases at the end of this section.

II. LEAF SPOTS and TAR SPOT:

Causal Agents: Several genera of fungi: leaf spots (e.g., *Septoria, Phyllosticta, Didymosporina*), tar spots (*Rhytisma acerinum, R. americanum,* and *R. punctatum*)

Symptoms: All species of maple are subject to attack by one or more leaf-spotting fungi. Symptoms usually appear in mid to late summer.

- **Leaf Spots:** Symptoms appear as circular to irregular spots approximately ¼ to 1 inch in diameter. Some spots have tan to brown centers and distinct purple-brown margins (sometimes referred to as a "frog-eye" symptom) whereas other spots are dark brown and have diffuse, concentric ring patterns and irregular margins (Figure 3). Small black fruiting bodies may be visible on the upper or lower surfaces of the spots. Spores of the fungi are often visible as tendrils oozing from the back fruiting bodies after periods of wet weather (Figure 4). These diseases are usually more severe on red, sugar, and silver maple but can occur on Japanese and Norway maple.

Figure 3. Septoria leaf spot of maple. Initial symptoms are small necrotic spots, which when numerous, can coalesce into large necrotic areas.

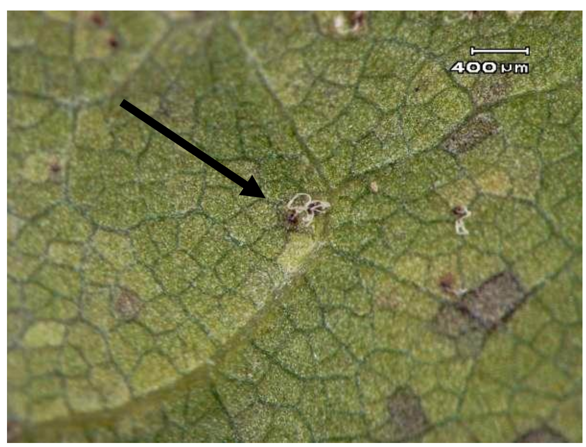

Figure 4. Close-up of tendril of oozing fungal spores (arrow) on abaxial surface of a leaf.

- **Tar Spot:** Symptoms first appear as inconspicuous, pale green to yellow areas on the leaves. As the fungus grows within the leaf, these areas develop into distinctive, slightly raised, shiny, tar-like, black spots on the leaves (Figure 5). The size of the spot depends upon the fungal species; spots can be irregular and up to ½ inch in diameter (*R. acerinum*) or can appear as tiny, pinpoint dots (*R. punctatum*) (Figure 6). Significant premature fall coloration and defoliation can occur, especially when infection is heavy (as is often the situation on Norway maple).

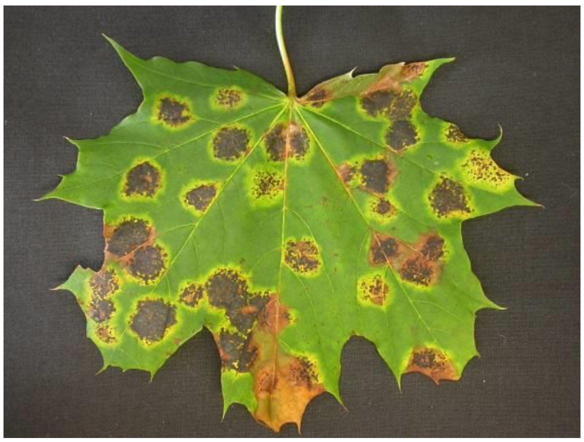

Figure 5. Tar spot on maple.

Figure 6. Close-up of the tar-like stroma of the fungus, *Rhytisma* spp.

Management: Refer to management strategies for foliar diseases at the end of this section.

III. POWDERY MILDEW:

Causal Agent: Several genera of fungi (e.g., *Erysiphe, Phyllactinia)*

Symptoms: Leaves develop a somewhat "dirty" appearance due to the presence of a white to grayish, powdery growth on the leaf surface (Figure 7). Symptoms are usually first evident on the upper surface of the leaf and can result in premature fall coloration. Unlike many other foliar diseases, powdery mildew typically develops late in the growing season. It can result in defoliation when infection is severe.

Figure 7. Diagnostic powdery growth on upper surface of a maple leaf.

Management: Refer to management strategies for foliar diseases at the end of this section.

Management Strategies for Foliar Diseases: Control of anthracnose, leaf spots, and powdery mildews can be achieved using a multifaceted approach. These diseases are often effectively controlled by following good sanitary and cultural practices and are rarely serious enough to warrant chemical control. Since many of these fungi overwinter on fallen leaves, it is important to rake and remove fallen leaves from the vicinity of the tree in autumn. This reduces the number of spores available to infect emerging leaves in spring or during the following growing season. Tree vigor should also be maintained by proper watering, fertilizing, and pruning. Although foliar diseases are usually considered to be more aesthetic than life-threatening, there are situations where they can be serious and cause permanent damage or even tree death. Newly transplanted trees or trees weakened by stress are particularly sensitive to repeated defoliation. In such cases, chemical control can be beneficial. Among the fungicides registered for homeowner use in Connecticut are thiophanate-methyl, chlorothalonil, and mancozeb. The pesticide label will contain information on dosage rates, application intervals, and safety precautions. Since most of these fungi infect in spring as leaves are unfolding, the first fungicide spray is applied at budbreak. Two or three additional sprays are subsequently applied at 7-14 day intervals. Additional applications may also be necessary in unusually wet springs. For anthracnose and leaf spots, once symptoms are visible on the leaves it is too late for chemical control. (The exception to early season infections are the powdery mildews. They usually infect in mid-season so applications of fungicides for control would be applied as soon as symptoms are visible.)

IV. VERTICILLIUM WILT:

Causal Agent: *Verticillium* spp.

Symptoms: Symptoms of Verticillium wilt first appear as a yellowing or wilting of individual limbs or portions of the canopy (often referred to as "flagging") (Figures 8 and 9). This usually occurs in mid-summer, frequently after periods of hot, dry weather. The fungus enters the roots and grows into the water transport system (xylem) of the tree where it restricts the movement of water and nutrients within the tree. Infected trees often have sparse canopies consisting of undersized, off-colored leaves. These trees sometimes produce heavy crops of seeds or samaras. A diagnostic characteristic of this disease is a distinctive olive-brown streaking, which may be evident in the wood of symptomatic branches or twigs (Figure 10).

Figure 8. Japanese maple with acute symptoms of Verticillium wilt.

Figure 9. Maple with a portion of the canopy exhibiting premature fall coloration.

Infected trees die slowly or suddenly, depending upon the extent of infection and the overall health of the tree. Trees weakened by drought or root damage are thought to be more prone to disease.

Figure 10. Diagnostic vascular discoloration in sapwood of maple infected with Verticillium wilt.

Management Strategies for Verticillium Wilt: There are no satisfactory controls for this disease of maple once trees are infected. However, efforts to maintain tree health and vigor can help to prolong the life of the tree. It is helpful to prune affected limbs as soon as symptoms are evident. This helps to minimize secondary invaders and opportunistic pests. Tools should be disinfested between cuts with a 10% solution of household bleach or 70% alcohol. Additional efforts to promote tree vigor by watering, fertilizing (only as necessary, based on a soil test) and avoiding other types of stress are helpful. Since the fungus is soil-borne, it is necessary to avoid planting susceptible species in the area. A list of resistant species can be found in Table 1 at the end of this fact sheet.

V. SCORCH:

Causal Factors: Drought and heat stress
Symptoms: Symptoms usually develop after periods of hot, dry weather in July and August. Leaves appear curled at the edges and cupped; they may develop brown, necrotic or dead margins (Figures 11, 12, and 13).

Figure 11. Japanese maple leaves with marginal scorch symptoms

Figure 12. Marginal scorch.

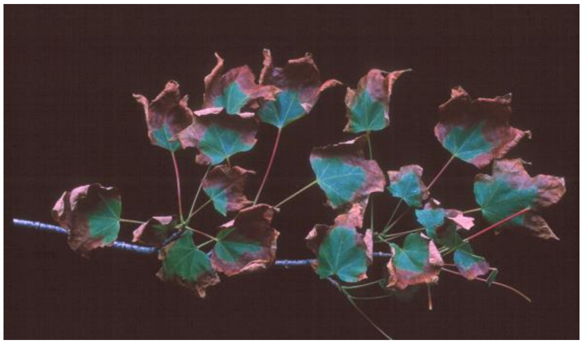

Figure 13. Characteristic marginal scorch symptoms.

Leaves also shrivel and drop prematurely. Since the symptoms can be confused with those associated with anthracnose, careful examination is necessary for accurate diagnosis.

Management Strategies for Scorch: Although the weather cannot be controlled, and there are no "cures" once the damage is done, there are steps that can minimize the effects of scorch. These include maintaining optimum growth and vigor by watering during periods of drought, fertilizing at the proper time to avoid growth late in the season that may not harden-off properly for the winter, and pruning to remove dead twigs or branches to minimize secondary invaders or opportunistic pests.

Table 1. Resistance of Selected Woody Ornamentals to Verticillium Wilt

Resistant or Immune	Susceptible
Apple *(Malus)*	Ash *(Fraxinus)*
Arborvitae *(Thuja)*	Azalea *(Rhododendron)*
Beech *(Fagus)*	Barberry *(Berberis)*
Birch *(Betula)*	Black Locust *(Robinia)*
Boxwood *(Buxus)*	Box Elder *(Acer negundo)*
Butternut *(Juglans)*	Boxwood *(Buxus)*
Crabapple *(Malus)*	Catalpa *(Catalpa)*
Dogwood *(Cornus)**	Cherry, other stone fruits *(Prunus)*
Fir *(Abies)*	Coffee tree, Kentucky *(Gymnocladus)*
Firethorn *(Pyracantha)*	Currant *(Ribes)*
Gingko *(Gingko)*	Dogwood *(Cornus)**
Hackberry *(Celtis)*	Elm *(Ulmus)*
Hawthorn *(Crataegus)*	Honeysuckle *(Lonicera)*
Hickory *(Carya)*	Lilac *(Syringa)*
Holly *(Ilex)*	Linden *(Tilia)**
Honey Locust *(Gleditsia)*	Magnolia *(Magnolia)*
Hornbeam *(Carpinus)*	Maple *(Acer)*
Juniper *(Juniperus)*	Redbud *(Cercis)*
Katsura tree *(Cercidiphyllum)*	Rose *(Rosa)*
Larch *(Larix)*	Russian Olive *(Elaeagnus)*
Linden *(Tilia)**	Serviceberry *(Amelanchier)**
Mountain Ash *(Sorbus)*	Smoke tree *(Cotinus)*
Mulberry *(Morus)*	Spirea *(Spirea)*
Oak *(Quercus)*	Sumac *(Rhus)*
Pear *(Pyrus)*	Viburnum *(Viburnum)*
Pine *(Pinus)*	Weigela *(Weigela)*
Poplar *(Populus)*	Yellowwood *(Cladratis)*
Serviceberry *(Amelanchier)**	
Spruce *(Picea)*	
Sweet Gum *(Liquidambar)*	
Sycamore *(Platanus)*	
Walnut *(Juglans)*	
Willow *(Salix)*	
Yew *(Taxus)*	

* The resistance or susceptibility of these plants will depend upon the cultivar of the tree and the strain of *Verticillium* present in the soil.

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Dr. Sharon M. Douglas
Department of Plant Pathology and Ecology
The Connecticut Agricultural Experiment Station
123 Huntington Street, P. O. Box 1106
New Haven, CT 06504

Phone: (203) 974-8601
Fax: (203) 974-8502
Email: Sharon.Douglas@ct.gov
Website: www.ct.gov/caes

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COMMON PROBLEMS OF MOUNTAIN LAUREL

Mountain laurel, *Kalmia latifolia*, is a native plant and the state flower of Connecticut. There are several diseases that commonly occur on mountain laurel in landscapes and nurseries throughout the state every year. These include fungal leaf spots and blights, winter injury, drought injury, and chlorosis. The occurrence and severity of these diseases are influenced by many factors, including the severity of infection and amount of overwintering inoculum from the previous year, the weather at the time of leaf emergence, cultural practices, and the species or cultivar planted.

FUNGAL LEAF SPOTS AND BLIGHTS

Causal Agents: Several genera of fungi are associated with leaf spots (e.g., *Cercospora*, *Phyllosticta*, *Septoria)* and leaf blights (e.g., *Phomopsis*).

Symptoms: Symptoms of leaf spots and leaf blights usually develop on current season foliage of mountain laurel in mid to late summer. However, in rare cases, infections may not be visible until the following winter or spring after infection. Leaf spots appear as dead areas of tissue scattered over the surface of the leaf. They usually have distinct margins that are often darker than the brown, black, tan, or reddish centers. Spots are usually visible on both upper and lower leaf surfaces (Figures 1 and 2). However, the spots can vary in size from pin-head to those that are more diffuse or even coalesce over the entire leaf. Small, black fruiting bodies may be visible in the spots (Figure 3).

Figure 1. Fungal leaf spot of mountain laurel.

Figure 2. Characteristic leaf spots with distinct margins and tan centers.

Figure 3. Close-up of small fruiting bodies of the fungus in the leaf spot lesion (arrows).

Tan masses of fungal spores can sometimes be seen oozing from the black fruiting bodies after periods of wet weather. These tendrils consist of masses of individual fungal spores that are readily wind- or rain- driven to newly emerging leaves in spring.

Leaf blights have different characteristics than leaf spots. In particular, the brown lesions are larger than leaf spots and have a zonate pattern (Figures 4, 5, and 6). The lesions also often develop along the leaf margin or tip of the leaf. When they coalesce, the entire leaf turns brown and drops.

Management: Fungal leaf spots and blights can be managed using a variety of strategies. They are rarely serious enough to warrant chemical control and are often effectively managed by following good sanitary and cultural practices. In fall, it is important to rake and remove fallen leaves from the vicinity of the shrub since many of the leaf-spotting fungi overwinter on fallen leaves and plant debris. This practice reduces the number of spores available to infect emerging leaves in spring.

It is also important to follow sound cultural methods that promote plant vigor. These include proper watering, fertilizing, and mulching, and appropriately timed pruning, and managing insects, particularly the black vine weevil. Leaf spots and blights are most severe under crowded and shaded conditions.

Figure 4. Symptoms of leaf blight appear as large, brown blotches that can involve large portions of the leaf.

Figure 5. Blotchy, necrotic lesions associated with leaf blight.

Figure 6. Diagnostic zonate pattern associated with leaf blight. Note the small black fruiting bodies visible in the lesion (arrows).

Differences in susceptibility to leaf spots have been reported for some cultivars of mountain laurel. Among cultivars with good resistance to leaf spots are Carousel, Carol, Nathan Hale, Olympic Fire, and Pinwheel.

In some cases, leaf spots and blights can become serious and result in injury (i.e., branch and twig dieback) or even plant death. This is especially problematic on new transplants or on weakened or stressed plants. In such cases, chemical control is often necessary, especially in cool, wet springs. Several fungicides are registered for use in Connecticut, including thiophanate-methyl, chlorothalonil, and mancozeb. Organic options include sulfur and copper compounds. Several biological products can also be used as protectants. These include *Trichoderma harzianum* Rifai strain KRL-AG2, *Streptomyces griseoviridis* strain K61, and *Bacillus subtilis* strain QST 713 may be effective as protectants. The pesticide labels contain information for use, including specific plant hosts and diseases, dosage rates, and safety precautions. Since most leaf-spotting fungi infect in spring as new leaves are emerging, the first fungicide spray is usually applied at bud break. Additional applications may also be necessary in unusually wet springs. When symptoms are visible on the new leaves, it is usually too late for effective chemical control.

WINTER INJURY

Causal Factors: This abiotic disorder can be attributed to diverse factors that include sudden temperature fluctuations, excessive or late season fertilization, lack of snow cover, drying winds, and late spring frosts. The most common type of winter injury on mountain laurel is excessive drying. This occurs when a water deficit develops in the plant--water lost through the leaves is not replaced because the roots cannot absorb enough water from cold or frozen soil.

Symptoms: Winter injury or winter drying of mountain laurel commonly occurs on plants growing in both wind-swept and sheltered locations. Symptoms often do not show up immediately after the damage has occurred, but might appear months later. Symptoms can develop on one or two individual branches or on the entire shrub (Figure 7). Winter injury also predisposes affected plants to secondary invaders or opportunistic pests.

Symptoms can appear as tip or marginal browning of leaves, dieback of twigs and branches, and desiccation of growing tips or twigs. Water evaporates from the leaves on windy or warm, sunny days and cannot be replaced since the water in the soil is still frozen or unavailable to the plant roots. Plants that have been recently transplanted and lack well-developed or established root systems are most susceptible to winter injury, as are established shrubs of all sizes and ages growing in full sun or whose root systems are predisposed and damaged by excess water or drought.

Figure 7. Winter injury symptoms on an established mountain laurel.

Management: Winter injury does not generally contribute to long-term issues with plant health. However, it can be disconcerting, because of the eye-catching damage that can occur. It can also be stressful when it occurs on new transplants or when damage occurs for several consecutive years. While there is no cure for this physiological disorder, there are steps to help minimize its effects. These include selecting an appropriate site for planting and maintaining plant vigor by following sound cultural practices. Deep watering the plants before the ground freezes in the fall and mulching around the base of the plant can provide and maintain sufficient moisture in the root zone. Fertilizing at the proper time and rate can be helpful, especially avoiding late summer and early fall fertilization, which encourages growth that does not harden off properly for winter conditions. Good sanitation is also helpful, by pruning out dead, dying, or damaged branches in spring to minimize potential problems with secondary invaders and opportunistic pests. For new transplants and plants in exposed locations, providing physical protection from water loss and drying winds can be helpful. Burlap wraps and sprays of anti-transpirants or anti-desiccants can be effective.

DROUGHT INJURY

Causal Factors: This abiotic disorder is caused by the absence of rainfall for a period of time long enough to deplete the soil of available moisture and cause damage to plants.

Symptoms: Although mountain laurel is sometimes listed as tolerant to drought, it is often affected by drought, especially when plants are growing in thin soils with limited organic matter. Symptoms include loss of turgor in leaves, drooping, wilting, yellowing, premature leaf drop, bark cracks, and twig and branch dieback (Figure 8).

Figure 8. Naturally occurring mountain laurel with very sparse canopy and symptoms of wilt and dieback associated with drought.

Drought has primary physical effects, which include direct damage to the roots and root death, especially of non-woody feeder roots and root hairs. This results in the loss of root function, which creates a water deficit in the plant. Drought also has significant secondary physical effects whereby plants are weakened and pre-disposed to secondary invaders and opportunistic pests such as winter injury, root rots, and insects. Drought is also associated with increased problems with transplant failures.

In addition to direct (physical) damage to the root system, drought triggers metabolic changes in the plant. Among these are changes in hormone levels and other physiological factors (e.g., factors that influence the number of leaves that will emerge the next year or that are responsible for the closing of stomates).

The effects of drought often do not show up until after the damage has occurred, sometimes as much as one year later. Symptoms can develop on one or two individual branches or on the entire shrub.

Mountain laurels that have been recently transplanted and lack well-developed or established root systems are most susceptible to drought, as are established shrubs of all sizes and ages whose root systems are predisposed and damaged by excess water or poor planting.
Management: Drought, like winter injury, does not generally contribute to long-term issues with plant health. However, it can be stressful when it occurs on new transplants or when drought conditions occur for several consecutive years. While there is no cure for this physiological disorder, there are steps to help minimize its effects. These include selecting an appropriate site for planting and maintaining plant vigor by following sound cultural practices. Watering in periods of low soil moisture and mulching around the base of the plant can provide and maintain sufficient moisture in the root zone. Most plants need about 1 inch of water per week. For most soil types, water is best applied at one time as a slow, deep soaking of the entire root zone to a depth of approximately 12-18 inches. The length of time required to "deep-water" will vary with soil type and water pressure: clay soils usually require more time than sandy soils. Frequent, light, surface watering will ***not*** help the plant and can actually cause harm by promoting growth of surface roots. A deep soaking just before the ground freezes in the fall will also help the winter hardiness of drought-stressed mountain laurels.

Good sanitation is also helpful, and consists of pruning out dead, dying, or damaged branches in spring to minimize potential problems with secondary invaders and opportunistic pests.

CHLOROSIS

Causal Factors: This physiological disorder occurs when mountain laurel grows in soils with pH levels above 6.0-6.5. This results in iron chlorosis and micronutrient deficiencies.
Symptoms: Mountain laurel growing in naturally alkaline soils, near new cement walls or foundations, or in heavy or poorly drained soils often develops chlorotic or yellowed leaves. Under the former two conditions of high soil pH, plants are unable to absorb iron. This results in a deficiency that leads to yellowing or interveinal chlorosis--where the leaf veins remain green and the area between the veins turns yellow. These symptoms usually develop on the youngest foliage first. Iron is not necessarily deficient in the soil—it may be there, but just in an unavailable form for absorption through the root system as a result of the soil pH.

Figure 9. Chlorotic leaves appear pale green to yellow, but the veins remain green.

Management: This physiological disorder can usually be corrected by treating the soil with an iron chelating compound or by lowering the soil pH (to pH 5.5 or below) using soil amendments such as sulfur, iron sulfate, or ammonium sulfate. These amendments must be thoroughly incorporated into the root area in order to be effective. Therefore, it is very helpful to have the soil tested prior to planting; this will also provide information on rates for the amendments. Leaf chlorosis can be temporarily remediated by spraying the foliage with iron compounds such as iron sulfate, iron chelate, and soluble organic iron complexes.

Under conditions of heavy or water-logged soils, leaves yellow because plants are unable to absorb nutrients because the feeder roots have been damaged by excessive soil moisture and lack of oxygen. This condition is often irreversible, especially if damage is extensive. However, if the problem is recognized early, efforts to improve soil texture and drainage can promote root health and improve root function.

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Dr. Sharon M. Douglas
Department of Plant Pathology and Ecology
The Connecticut Agricultural Experiment Station
123 Huntington Street, P. O. Box 1106
New Haven, CT 06504

Phone: (203) 974-8601
Fax: (203) 974-8502
Email: Sharon.Douglas@ct.gov
Website: www.ct.gov/caes

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COMMON PROBLEMS OF RHODODENDRON AND AZALEA

There are several diseases that commonly occur on rhododendrons and azaleas in landscapes and nurseries every year in Connecticut. These include fungal leaf spots, leaf and flower gall, root rot, oedema, leaf flooding, winter injury, and chlorosis. However, the occurrence and severity of these diseases are influenced by many factors, such as the level and severity of infection and overwintering inoculum from the previous year, the weather at the time of leaf emergence, cultural practices, and the species or cultivar planted.

FUNGAL LEAF SPOTS

Causal Agents: Several genera of fungi (e.g., *Cercospora*, *Colletotrichum*, *Septoria*, and occasionally, *Pestalotiopsis*).

Symptoms: Many cultivars of rhododendron and azalea can be infected by one or more leaf-spotting fungi. Symptoms usually develop on current season foliage in mid to late summer. However, in some cases, infections may not be visible until the following winter or spring after infection. Leaf spots appear as dead areas of tissue scattered over the surface of the leaf. They usually have distinct margins that are often darker than the brown, black, tan, or reddish centers. Spots are usually visible on both upper and lower leaf surfaces (Figures 1 and 2). However, the spots can vary in size from pinhead to those that are more diffuse or even coalesce over the entire leaf. Small, black fruiting bodies may be visible on the upper or lower surfaces of the spots (Figure 3).

Figure 1. Fungal leaf spot of rhododendron.

Figure 2. Characteristic leaf spots with distinct margins.

Tan masses of fungal spores can sometimes be seen oozing from the black fruiting bodies after periods of wet weather. These tendrils consist of masses of individual fungal spores that are readily wind- or rain-driven to newly emerging leaves in spring (Figure 4).

Figure 3. Small, black fruiting structures of the fungus are visible in the leaf spots.

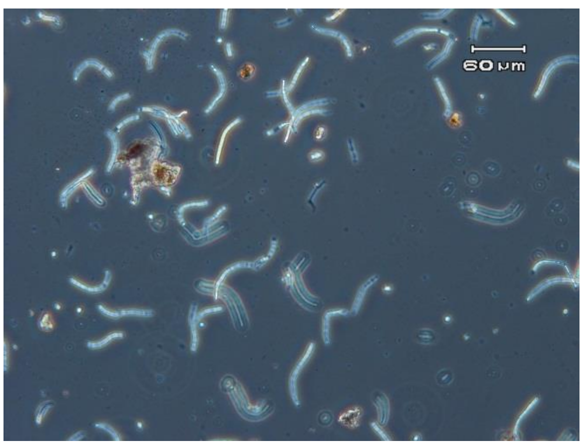

Figure 4. Photomicrograph of spores of the leaf spot fungus *Cercospora*.

Management: Fungal leaf spots can be managed using a variety of strategies. Leaf spots are rarely serious enough to warrant chemical control and are often effectively managed by following good sanitary and cultural practices. In autumn, it is important to rake and remove fallen leaves from the vicinity of the shrub since many of the leaf-spotting fungi overwinter on fallen leaves and plant debris. This practice reduces the number of spores available to infect emerging leaves in spring.

It is also important to follow sound cultural methods that promote plant vigor. These include proper watering, fertilizing, and mulching, appropriately timed pruning, and managing insects, particularly the black vine weevil.

In some cases, leaf spots can become serious and result in injury (i.e., branch and twig dieback) or even plant death. This is especially problematic on new transplants or on weakened or stressed plants. In such cases, chemical control is often necessary, especially in cool, wet springs. Several fungicides are registered for use in Connecticut, including thiophanate-methyl, chlorothalonil, and mancozeb. Organic options include sulfur and copper compounds. Several biological products can also be used as protectants. These include *Trichoderma harzianum* Rifai strain KRL-AG2, *Streptomyces griseoviridis* strain K61, and *Bacillus subtilis* strain QST 713 may be effective as protectants. The pesticide labels contain information for use, including specific plant hosts and diseases, dosage rates, and safety precautions. Since most leaf-spotting fungi infect in spring as new leaves are emerging, the first fungicide spray is usually applied at bud break. Additional applications may also be necessary in unusually wet springs. When symptoms are visible on the new leaves, it is usually too late for effective chemical control.

LEAF AND FLOWER GALL

Causal Agents: Several species of the fungal genus *Exobasidium*.

Symptoms: Diagnostic symptoms develop on young leaves of azaleas and occasionally on rhododendrons in the early spring. Some of the native rhododendron species (azaleas) are more susceptible than hybrid rhododendrons. Leaves and buds are infected as they emerge in April and May. Affected leaves, stems, and flowers become distorted, thickened, and bladder-like. They are succulent and fleshy (Figures 5 and 6).

Figure 5. Young, pale green, fleshy gall on azalea.

Figure 6. Older azalea leaf gall covered with the white spores of the fungus.

Galls are initially pale green in color, but develop a white "bloom," which consists of spores of the causal fungus. The galls eventually turn red and brown and shrivel into hard masses (Figure 7). The severity of the disease usually depends on the weather and history of disease. Favorable weather includes prolonged bud break due to cool temperatures and adequate rainfall or dew to provide free water on the plant tissues. The fungus overwinters in bud scales and infects tender tissues as they are emerging.

Figure 7. An aging gall that is turning brown and shriveling.

Management: Leaf and flower galls are generally not serious, although they can be disconcerting, because of their eye-catching appearance. They generally do not contribute to long-term plant health issues. However, when this disease re-occurs for several consecutive years, especially on new transplants, it can reduce plant vigor.

When only a few plants are involved, this disease can be managed by hand picking and discarding the galls. It is important to pick the galls before the white layer of spores appears. Plants growing in sites with poor air circulation or poorly drained soil are more susceptible, so anything that can be done to remediate these conditions can be helpful in managing the disease.

Fungicide applications are generally not warranted or efficacious in home landscapes.

Differences in susceptibility and resistance to leaf and flower gall has been reported for azalea and rhododendron. Azalea: some highly susceptible cultivars include the Indica group; resistant cultivars include Formosa, Sensation, and Aphrodite.

Rhododendron: some highly susceptible species are *R. maximum*, *R. catawbiense*, and their hybrids.

PHYTOPHTHORA ROOT ROT

Causal Agents: Several species of the genus *Phytophthora*, an oomycete or fungus-like organism (e.g., *P. cactorum*, *P. cinnamomi).*

Symptoms: Phytophthora root rot is a serious disease of landscape as well as field- and container-grown nursery plants. Above-ground symptoms of Phytophthora root rot are generally non-specific and non-diagnostic. Initial symptoms consist of slow growth, slightly off-colored foliage, and drooping or wilting of the foliage, especially in mid-day. As the disease progresses, more dramatic above-ground symptoms develop, which include twig and branch dieback and inward curling and drooping of olive-green leaves (Figure 8).

More diagnostic symptoms are visible in the root and crown area and roots. Infection begins as the pathogen enters root hairs and non-woody roots. Infected roots appear waterlogged and blackened; the outer cortex often pulls away from the stele. The pathogen then grows into larger-diameter roots and into the root crown. Plants can be girdled as the pathogen moves up the stem. The cambium is killed and turns a diagnostic cinnamon-brown. Without a functional root system, leaves become chlorotic, roll downward toward the midrib, and gradually wilt. Highly susceptible, young, container-grown rhododendrons may die within 14 days. Older, landscape plants may gradually develop symptoms before eventually dying, or may show minimal above-ground symptoms until additional stresses cause the weakened plants to die. Phytophthora root rot can be confused with mechanical damage, soil compaction, nematode damage, and other root diseases.

Figure 8. Diagnostic olive-green, inward curling leaves associated with Phytophthora root rot.

Phytophthora root rot is often associated with drainage problems and wet sites. This soilborne pathogen (previously called a "water mold") produces motile spores that readily move in water. As a consequence, declining plants often follow drainage patterns, especially in chronically low, wet areas or on hills. Infections occur after periods of standing water or follow drainage patterns. Depending on the species, two types of resistant resting structures (chlamydospores and oospores) can form in infected roots. These allow the pathogen to survive in the soil for quite some time during unfavorable conditions. In warm and saturated soils (even for a few hours), chlamydospores and oospores germinate to form sporangia. Sporangia form and release swimming zoospores. Zoospores "swim" in free water and are attracted to nearby roots, especially root tips or injured roots. Zoospores invade the root hairs and roots. The longer the soil is saturated, the more severe the infection. The greater the number of periods of saturated soil, the more severe the infection. The optimum temperature for disease range from 59-77 °F for most infections, although cooler temperatures can also be conducive to infection. Roots are most susceptible during the spring and fall, which corresponds to the same time that soil temperatures are most favorable for zoospore production and activity. When plants are dormant, rootstock susceptibility and pathogen activity are both low.

Management: Phytophthora root rots are most effectively managed in the landscape by prevention. This includes purchasing healthy, pathogen-free plant material, by careful attention to the characteristics of the site selected for planting, and the planting practices. Sites should be well-drained. Additional site modifications that can be effective include planting on raised beds or installing drain tiles to direct water away from the root zone.

Once the disease is detected, infected plants should be removed from the planting. Since high nitrogen favors disease, it is helpful to avoid using fertilizers high in nitrogen or to apply a low rate of slow-release fertilizer.

Differences in susceptibility and resistance to Phytophthora root rot has been reported for azalea and rhododendron. Rhododendron hybrids with good resistance to *P. cinnamomi* include Caroline, Martha Isaacson, Pink Trumpet, Professor Hugo de Vries, and Red Head; with moderate resistance: Bosley, Brickdust, Aureum, and English Roseum. Rhododendron species with good or moderate resistance include *R. delavayi*, *R. glomerulatum*, *R. hyperythrum*, *R. lapponicum*, *R. ciliatum*, *R. hemitrichotum*, *R. shwelliense*, *R. simiarum*, *R. spiciferum*, and ***R.*** *yunnanense.* Azalea cultivars with resistance include Alaska, Chimes, Corrine Murrah, Formosa Fred Cochran, Rachel Cunningham, and Redwing.

Fungicide applications are not curative and are usually not effective once plants are infected. However, they can be helpful to protect uninfected plants and prevent spread of the pathogen to adjacent healthy plants. These should be used in conjunction with cultural methods previously mentioned in order to be most effective. Among the fungicides registered in Connecticut are mefenoxam, metalaxyl, fosetyl-Al, etridiazole, etridiazole + thiophanate-methyl, and phosphorous acids. The pesticide labels will contain information for use with specific plant hosts, dosage rates, and safety precautions.

OEDEMA

Causal Factors: This physiological disorder is associated with a water imbalance that develops in leaves. This occurs when the air is moist and cool and the soil is moist and relatively warm. The roots take up more water than the plant can use or transpire through the stomates.

Symptoms: Initial symptoms appear as pale, chlorotic spots on the upper leaf surfaces. Diagnostic symptoms develop on the abaxial surfaces and appear as water-soaked blisters that eventually become brown and corky (Figures 9 and 10). At quick glance, they can be confused with scale or other insect pests. When severe, leaves can yellow and drop prematurely. Oedema is most prevalent in the late winter especially during extended periods of cool, cloudy weather.

Management: Oedema can be managed by attention to plant spacing to improve the flow of air over the leaves and reduce relative humidity. Symptomatic plants often recover from oedema when more favorable growing conditions return in spring and early summer.

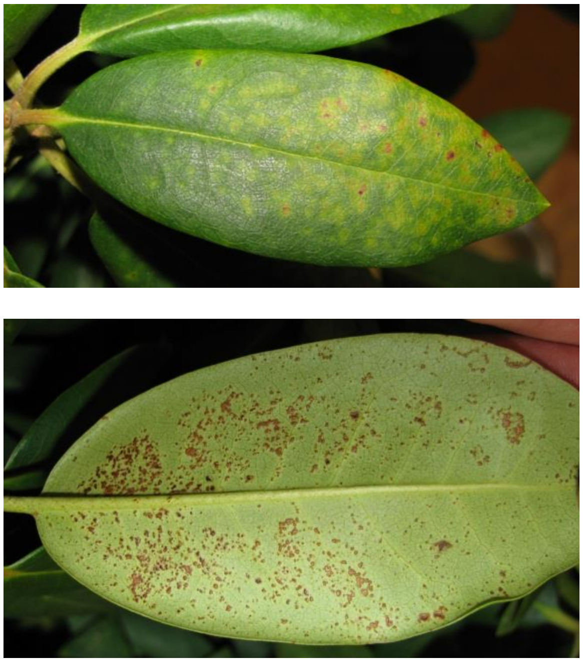

Figure 9. Oedema of rhododendron: upper leaf surface with pale chlorotic areas (top photo); brown, corky blisters (bottom) associated with oedema.

Figure 10. Close-up view of corky oedema lesions.

LEAF FLOODING

Causal Factors: This is a physiological disorder associated with movement of excess water into the leaves by root pressure at the same time that transpiration is inhibited by high relative humidity. This can develop on plants in winter storage when conditions are designed to provide high relative humidity using polyethylene "blankets" as a vapor barrier in order to prevent leaf damage from desiccation, especially while rootballs are frozen. This condition rarely develops in field-grown or landscape plants.

Symptoms: Leaves initially develop dark, water-soaked blotches as a result of water infiltrating the intercellular spaces, especially along the mid-vein. Under normal conditions, these air-filled intercellular spaces comprise 10-20% of the leaf. The extent of flooding depends upon the duration of favorable conditions and cultivar. On some plants, flooding can disappear after conditions improve. On others, the blotchy areas become necrotic (Figure 11). Nova Zembla is highly susceptible whereas Roseum Elegans rarely develops leaf flooding symptoms.

Figure 11. Rhododendron leaves with symptoms of leaf flooding.

Management: Symptoms of leaf flooding and conditions that favor its development should be monitored, especially after an extended period of rainy weather during storage. Venting storage facilities for a day or two when the weather clears should cause the flooding to disappear.

WINTER INJURY

Causal Factors: This abiotic disorder can be attributed to diverse factors that include sudden temperature fluctuations, excessive or late season fertilization, lack of snow cover, drying winds, and late spring frosts. The most common type of winter injury on rhododendron is excessive drying. This results from factors that create a water deficit in the plant. This type of injury occurs when water evaporates from leaves on windy or warm, sunny days during the winter or early spring. Drying occurs because this water is not replaced, since the roots cannot take up enough water from cold or frozen soil.

Symptoms: Winter injury or winter drying of rhododendron and azalea commonly occurs on plants growing in both wind-swept and sheltered locations. This is a general term applied to a group of environmentally-caused problems that have little in common other than they occur during the winter. Winter injury is important in and of itself, but it also predisposes the plants to secondary invaders or opportunistic pests. Quite often, the effects do not show up immediately after the damage has occurred. Symptoms can develop on one or two individual branches or on the entire shrub (Figure 12). They can appear as tip or marginal browning of leaves, dieback of tips and branches, desiccation of growing tips or twigs, and longitudinal rolling of leaves along the mid-vein (Figures 13 and 14). Water evaporates from the leaves on windy or warm, sunny days and cannot be replaced since the water in the soil is still frozen or unavailable to the plant roots.

Figure 12. Winter injury symptoms on one portion of an established plant.

Figure 13. Diagnostic symptoms of winter injury including rolling of the leaves along the mid-vein.

Figure 14. Close-up of winter injury symptoms.

Plants that have been recently transplanted and lack well-developed or established root systems are most susceptible to winter injury, as are established shrubs of all sizes and ages whose root systems are predisposed and damaged by excess water or drought.

Management: Winter injury does not generally contribute to long-term issues with plant health. However, it can be disconcerting, because of the eye-catching damage that can occur. It can also be stressful when it occurs on new transplants or when damage occurs for several consecutive years. While there is no cure for this physiological disorder, there are steps to help minimize its effects. These include selecting an appropriate site for planting and maintaining plant vigor by following sound cultural practices. Deep watering the plants before the ground freezes in the fall and mulching around the base of the plant can provide and maintain sufficient moisture in the root zone. Fertilizing at the proper time and rate can be helpful, especially avoiding late summer and early fall fertilization, which encourages growth that does not harden off properly for winter conditions. Good sanitation is also helpful, by pruning out dead, dying, or damaged branches in spring to minimize potential problems with secondary invaders and opportunistic pests. For new transplants and plants in exposed locations, providing physical protection from water loss and drying winds can be helpful. Burlap wraps and sprays of anti-transpirants or anti-desiccants can be effective.

CHLOROSIS

Causal Factors: This physiological disorder occurs when rhododendrons and azaleas grow in soils with pH levels above 6.0-6.5. This results in iron chlorosis and micronutrient deficiencies.

Symptoms: Rhododendrons and azaleas growing in naturally alkaline soils, near new cement walls or foundations, or in heavy or poorly drained soils often develop chlorotic or yellowed leaves. Under the former two conditions of high soil pH, plants are unable to absorb iron. This results in a deficiency that leads to yellowing or interveinal chlorosis--where the leaf veins remain green and the area between the veins turns yellow. These symptoms usually develop on the youngest foliage first. Iron is not necessarily deficient in the soil—it may be there, but just in an unavailable form for absorption through the root system as a result of the soil pH.

Management: This physiological disorder can usually be corrected by treating the soil with an iron chelating compound or by lowering the soil pH (to pH 5.5 or below) using soil amendments such as sulfur, iron sulfate, or ammonium sulfate. These amendments must be thoroughly incorporated into the root area in order to be effective. Therefore, it is very helpful to have the soil tested prior to planting; this will also provide information on rates for the amendments. Leaf chlorosis can be temporarily remediated by spraying the foliage with iron compounds such as iron sulfate, iron chelate, and soluble organic iron complexes.

Under conditions of heavy or water-logged soils, leaves yellow because plants are unable to absorb nutrients because the feeder roots have been damaged by excessive soil moisture and lack of oxygen. This condition is often irreversible, especially if damage is extensive. However, if the problem is recognized early, efforts to improve soil texture and drainage can promote root health and improve root function.

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Dr. Sharon M. Douglas
Department of Plant Pathology and Ecology
The Connecticut Agricultural Experiment Station
123 Huntington Street, P. O. Box 1106
New Haven, CT 06504

Phone: (203) 974-8601
Fax: (203) 974-8502
Email: Sharon.Douglas@ct.gov
Website: www.ct.gov/caes

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DE-ICING SALTS: DAMAGE TO WOODY ORNAMENTALS

De-icing salts used to maintain ice-free roadways, driveways, and sidewalks can damage woody ornamental trees and shrubs in several ways. Although there has been increasing concern about the environmental impact and adverse effects of de-icing salts in recent years, these issues have been overshadowed by concerns for public safety. As much as 40-80 tons of salt per lane mile are applied to many highways for ice and snow control each year. The two most commonly applied de-icing salts are sodium chloride (rock salt) and calcium chloride. Although calcium chloride is a better material for melting ice, sodium chloride is used most extensively since it is less expensive and easier to handle. Unfortunately, sodium chloride is also more damaging to vegetation than calcium chloride. Most roads in Connecticut are now being treated with both types of salts: sodium chloride in solid and liquid form, and liquid calcium chloride.

Salt can injure plants at any time but applications in late winter (March) are thought to be more damaging than early-to mid-winter applications, since there is less time for winter snow and precipitation to leach the salts from the root zones.

SALT DAMAGE AND SYMPTOMS:

De-icing salts cause damage through direct contact of salt solutions with plant foliage (referred to as "spray zone" injury) (Figures 1 and 2) and through chemical and physical modification of the soil as a result of accumulating salt and uptake of salt ions by plant roots.

Spray zone injury results from the deposition of salt water on plant foliage and subsequent uptake of the salt by that foliage. Salt enters plant cells or the spaces between plant cells directly and can affect the hardiness of buds and small twigs.

Figure 1. Spray zone injury on conifers along a Connecticut highway. (Photo J. S. Ward, CAES)

Figure 2. Spray zone injury on white pine. (Photo J. S. Ward, CAES)

In the soil, dissolved salts separate into sodium and chloride ions which chemically, and to a certain extent physically, modify the soil. For example, the structure of the soil is altered when levels of sodium accumulate and cause clay particles to pack more densely. The chloride ions are readily taken up by the plant roots and transported to growing tips and foliage where they accumulate to toxic levels. In needles and leaves, these toxic accumulations result in marginal scorch or "burn" symptoms (Figure 3). The sodium ions also cause damage by competing with other ions in the soil. When high levels of sodium ions compete with lower levels of magnesium and potassium ions, it often results in selective uptake of sodium at the expense of the other two important nutrients. When this occurs, plants may develop deficiency symptoms, particularly those associated with potassium deficiency.

Symptoms of de-icing salt injury resemble those associated with root damage or drought stress. They vary with salt concentration, length of exposure, and plant species. Common symptoms include foliar browning, tip necrosis, marginal scorch, leaf/needle drop, tip and branch dieback, stunting, premature fall coloration (on deciduous species), death of vegetative and flower buds, and in extreme situations, outright tree death. One diagnostic feature of salt injury is that "spray zone" symptoms are often confined to the side of the tree or shrub facing the road and usually occur within 30-50 ft. of the road. Additionally, a gradient of damage can often be seen with trees or shrubs closer to the road showing more damage than those farther back.

Figure 3. Sugar maple with marginal scorch or "burn" associated with salt uptake.

Woody ornamentals show considerable variation in their relative tolerance to de-icing salts. However, research has demonstrated that trees and shrubs that have been weakened by drought-stress are more sensitive to de-icing salts than their healthy counterparts. Among those with high tolerance are Norway maple, autumn olive, white ash, white oak, honeylocust, Japanese black pine, white spruce, and yew. Moderately tolerant species include black cherry, green ash, American elm, Scots pine, and red cedar. Salt-sensitive species include winged euonymus, viburnum, sugar maple, dogwood, little-leaf linden, sycamore, eastern white pine, balsam fir and Canadian hemlock. More extensive lists are available upon request.

STRATEGIES TO MINIMIZE PROBLEMS WITH DE-ICING SALTS:

Although ***preventing*** problems with de-icing salts is certainly the best solution, it is not always practical or possible. However, the damage associated with de-icing salts can be managed or minimized using a number of different strategies. These include:

- **Washing salts off foliage**- Excess salts can be washed off foliage with fresh water and should be done as soon after exposure as possible.
- **Minimizing snow piles**- Avoid piling snow containing salt around plants or in places where the runoff will affect desirable plants. It is also helpful to alter road or walkway drainage patterns away from desirable plant species.
- **Removing sand-** With the recent movement towards using salt brines and salts in liquid and solid forms, this is not as common a problem. However, in areas where sand and salt combinations are still being used, buildup of sand can sometimes present additional problems. Sweeping, "brooming," or any other method that physically removes sand that has accumulated on the soil surface can be helpful. Since the type of sand applied to roads is extremely sharp, it is not a desirable addition to native soil. Thick layers of sand can also inhibit gas exchange and water penetration into the root zones of desirable plants.
- **Leaching salts-** To whatever extent possible, salts should be leached from the root zones of affected plants as soon as the ground is no longer frozen. *This is probably the most effective way to minimize soil salinity problems.* Repeated applications of fresh water will help to flush the salts down into the soil profile, below the root zones. The volume of water required to leach the salts will depend on the amount of salt in the soil. Leaching of excess salts can however, be difficult in heavy clay soils, which naturally don't have good internal drainage.
- **Amending soil**- Additives to the soil such as organic matter, activated charcoal, and gypsum can help with rectifying soil salinity problems. However, these are not quick fixes and if the salinity levels are extremely high, no amendments will reverse the situation. All additives, regardless of the material used, need to be incorporated into the soil, usually to a depth of at least 6 inches. This need to incorporate the amendment is one of the limiting factors in using soil additives to mediate road salt problems. Although a few reports suggest surface applications can be helpful (particularly for gypsum), the general consensus maintains that the additives need to be fully incorporated into the soil in order to be effective. Since plants growing in soils rich in organic matter show increased tolerance to salt, a program to increase organic matter in areas prone to road salt is a good preventative plan. Gypsum ($CaSO_4 \cdot 2H_2O$) is the most common additive used to counter salinity problems associated with sodium chloride, the most common de-icing salt. Gypsum separates into calcium and sulfate in the soil. The sulfate forms sulfuric acid in the soil and helps to neutralize any effect that calcium may have in raising the soil pH. The calcium replaces the sodium on the cation exchange sites. The sodium and sulfate form sodium sulfate ($NaSO_4$) which is a product that can be leached from the soil with water. Rates for gypsum applications depend on the salinity of the soil. However, rates in the range from 10-50 lbs. per 100 sq. ft. are commonly suggested.

- **Determining salt levels**- If concerned about the level of salt with which you're dealing, a soil test can help. Soil salinity is determined by measuring the electrical conductivity of the soil solution. This can be done with soil samples taken from the root zones of the areas in question. Testing for soluble salts is not part of the normal soil test performed by The Connecticut Agricultural Experiment Station. However, soluble salt levels can be tested *when requested at the time the soil sample is submitted for analysis.*
- **Selecting plants**- In areas where de-icing salt is likely to be a recurring, chronic problem, it is important to select and plant salt-tolerant species.
- **Maintaining plant vigor**- Maintain overall plant vigor by following sound cultural practices, which include watering during periods of drought, and pruning of dead or weakened branches or twigs in order to minimize problems with secondary or opportunistic pests.

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Dr. Sharon M. Douglas
Department of Plant Pathology and Ecology
The Connecticut Agricultural Experiment Station
123 Huntington Street, P. O. Box 1106
New Haven, CT 06504

Phone: (203) 974-8601
Fax: (203) 974-8502
Email: Sharon.Douglas@ct.gov
Website: www.ct.gov/caes

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DIPLODIA BLIGHT

Diplodia blight, formerly called Sphaeropsis tip blight, can be a destructive and devastating disease of pines, especially two- and three-needled species. Austrian, black, mugho, red, and Scots pine are very susceptible although many other species of pine are also affected, especially when growing under conditions of stress. Trees of all ages are susceptible although older trees frequently sustain greater damage and disfigurement.

SYMPTOMS AND DISEASE DEVELOPMENT:

Diplodia blight is caused by the fungus *Diplodia pinea*. This fungus usually attacks mature trees, although it is more damaging to trees that have been under stress from drought, excessive soil moisture, root restriction, other site problems, or biotic stresses. Symptoms often first appear on the current season's needles, since the fungus rapidly kills infected young, succulent shoots before the needles are fully elongated (Figures 1 and 2). As a consequence, needles on such shoots are often stunted. Infected shoots turn yellow, gradually brown, and fruiting structures of the fungus are visible as small, black structures with conical beaks at the base of the infected needles (Figures 3 and 4). A diagnostic feature of Diplodia blight is the presence of stunted, straw-colored shoots with short needles and excessive resin flow. In trees that are relatively free from stress, tip blight only kills the current-season buds, shoots, and second-year cones. Older twigs and branches are usually only damaged if trees are predisposed by stress, especially due to drought. This results in blighting and deformation of branches and limbs. In extreme cases, Diplodia blight can result in tree death.

Figure 1. Infected new shoots are stunted and killed before they elongate.

The Diplodia blight fungus can attack older shoots through wounds, including those caused by insect injury. These infections often result in perennial, bleeding twig and stem cankers but in severe cases can lead to girdling, branch death, and significant disfigurement of the tree.

Figure 2. Infected needles are stunted and tan.

Recent research suggests that the fungus is capable of causing latent infections that can go undetected until the tree is exposed to periods of stress, at which time the fungus is activated and typical dieback symptoms develop.

Figure 3. Black fruiting structures breaking through infected needles.

Cones are also infected by *P. pinea*. This usually occurs during their period of rapid growth in spring. Although cone infections are inconsequential for the general health of the tree, they are important for their contribution to the spread and severity of infections, since they contribute considerable fungal inoculum. Fruiting structures of the fungus are readily seen as small, black bodies on the cone scales.

Figure 4. Close-up of black, beaked fruiting structures emerging from symptomatic needles.

Diplodia blight is favored by wet spring weather, especially prolonged periods of budbreak, which promotes fungal growth and infection. Spores of the fungus are only spread during periods of rainfall and pines are particularly susceptible to infection in the early spring. Once again, trees which are predisposed by stress are much more susceptible than their stress-free counterparts.

DISEASE MANAGEMENT:

The effects of Diplodia blight can be minimized by following a multifaceted approach to management that includes sanitary, cultural, and chemical methods. It is *very* important to prune and remove as many blighted twigs, branches, and cones as possible during dry weather in autumn. This helps to reduce the amount of the fungus available to infect the new growth in the spring. It is often necessary to sacrifice and remove severely symptomatic trees to reduce the amount of inoculum. Trees should also be kept as vigorous as possible by following sound cultural practices to maintain tree vigor, controlling insect infestations, and watering during periods of drought. All unnecessary stresses such as soil compaction or equipment injuries should be avoided, if possible. Fungicide applications can also supplement other management strategies. Among the compounds registered for use in Connecticut are copper sulphate pentahydrate, mancozeb, mancozeb + copper hydroxide, propiconazole, and thiophanate-methyl. Consult the label for dosage rates and safety precautions. Since these fungicides act as protectant materials, they must be applied to the new growth as it emerges in spring. The first application should be made **before** any bud sheaths have broken and two or three additional applications can be made at label intervals, as necessary.

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Dr. Sharon M. Douglas
Department of Plant Pathology and Ecology
The Connecticut Agricultural Experiment Station
123 Huntington Street, P. O. Box 1106
New Haven, CT 06504

Phone: (203) 974-8601
Fax: (203) 974-8502
Email: Sharon.Douglas@ct.gov
Website: www.ct.gov/caes

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DOGWOOD ANTHRACNOSE

Dogwood anthracnose is considered the most serious disease of flowering dogwood (*Cornus florida*) in Connecticut and the Eastern Seaboard. It is also an important disease of Pacific Dogwood (*Cornus nuttallii*) in the West. The causal agent is the fungus *Discula destructiva*, and as the name suggests, this pathogen is highly destructive. It is believed that the fungus was probably simultaneously introduced into the East and West coasts of the United States in the mid-1970s. Since its introduction, dogwood anthracnose has resulted in the death of many dogwoods in forests, woodlots, and landscapes.

SYMPTOMS AND DISEASE DEVELOPMENT:

Initial foliar symptoms develop in May and June as brown spots up to ¼ inch in diameter that are visible on both the upper and lower leaf surfaces (Figure 1). These spots can be circular or irregular in shape and frequently develop distinctive smoky, purple-brown margins (Figure 2).

The flower bracts are also susceptible to infection and develop reddish or brownish spots or blotches. These are most prevalent when wet conditions occur during flowering. Under certain conditions, pinpoint, brownish-black fruiting structures can be

Figure 1. Necrotic spots on infected leaves.

Figure 2. Diagnostic, smoky, purple-brown margins are visible on foliar lesions.

seen in the centers of the foliar spots or lesions. Spots on the leaves usually become so numerous that they coalesce, which results in the development of large, dead areas on the leaves.

When entire leaves become necrotic, they usually droop and rather than falling off, they remain on the tree throughout the fall and into the winter. The persistence of infected leaves on the tree during winter is a distinctive characteristic and can help in diagnosis. The presence of infected leaves on the tree also serves as an important source of overwintering inoculum, since fungal spores capable of initiating new infections in spring are produced on these leaves.

When the whole leaf becomes infected, the fungus grows into the petiole and then into the twig where it causes cankers. Cankers are often tan, slightly sunken, elliptical areas of bark and are readily distinguished from surrounding healthy bark. The fungus can also directly infect shoots during spring and fall. These infections develop into very small cankers. If left unchecked, these cankers increase in size and eventually girdle the affected tissues (e.g., twigs, stems, branches, or the main trunk). Symptoms and branch dieback typically begin on the lower limbs and move progressively up the tree (Figure 3). This pattern of dieback appears to be associated with poor air circulation in the lower canopy, which results in tissues staying wet for longer periods of time. This makes them more susceptible to infection. Some trees attempt to compensate for the loss of limbs by sending out sprouts from the trunk (epicormic sprouts) but these sprouts are highly susceptible to infection. Sprout infections usually spread quickly to the trunk and cause severe cankers and splits in the bark. These cankers readily develop into tree-killing cankers.

Dogwood anthracnose is more aggressive on trees that have been predisposed or weakened by environmental and cultural factors. Among some of the more common predisposing factors are drought stress, poor site selection (e.g., full sun, windy or open area, or thin, or rocky soil), mechanical injury (e.g., damage from string trimmers and lawn mowers), and soil compaction.

Figure 3. Dieback of branches progressing from the bottom to the top of the tree.

DISEASE MANAGEMENT STRATEGIES:

The effects of dogwood anthracnose can be minimized by following an integrated approach toward managing the disease.

- Rake and remove fallen leaves to remove important sources of overwintering inoculum.

- Prune and remove cankered limbs and dead wood. This helps to reduce the ability of the fungus to grow into the main trunk where girdling, tree-killing cankers can develop.
- Maintain tree vigor by following sound cultural practices. It is especially important to avoid drought stress so watering the tree during periods of low rainfall is essential. Mulching is also helpful since it helps maintain soil moisture, moderate soil temperatures, and minimize chances for mechanical injuries.
- Provide adequate spacing for good air circulation. Since the fungus requires free water on plant surfaces in order to infect, any practices that reduce periods of wetness can help to minimize chances for infection.
- Control insects and avoid unnecessary mechanical injuries.
- Plant resistant species or cultivars. Although *Cornus kousa* (Kousa Dogwood) is less susceptible to infection than *C. florida* (Flowering Dogwood), it can become infected in years when there is heavy infection pressure and favorable weather for disease development. Breeding programs that have made crosses between *C. florida* and *C. kousa* have yielded promising cultivars such as the 'Stellar' Hybrid series, 'Aurora,' 'Celestial,' 'Constellation,' ‘Ruth Ellen,' 'Stardust,' and 'Stellar Pink.’
- Fungicides are another component of disease management. Applications can be made at budbreak, when the bracts fall, and 4 weeks later. A late-summer fungicide application when fruit and leaves begin to color has also been found to be helpful. Among the compounds registered for homeowner use in Connecticut are chlorothalonil, copper hydroxide, mancozeb, and thiophanate-methyl. Organic options for control include copper products, sulfur, *Bacillus subtilis* QST 713 strain (Serenade®), and potassium bicarbonate. Consult the label for dosage rates and safety precautions.

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FACT SHEET

DOOKS NEEDLE BLIGHT (FORMERLY CANAVIRGELLA NEEDLECAST) OF WHITE PINE

Dr. Sharon M. Douglas
Department of Plant Pathology and Ecology
The Connecticut Agricultural Experiment Station

Since 2009, many white pine in forests, woodlots, and landscapes throughout the Northeast have shown yellow and brown discoloration of current-season needles. Recurring outbreaks have also resulted in thin crowns and weakened trees due to stress caused by premature needle drop and loss of photosynthetic efficiency (Figure 1). Several fungal diseases were associated with this damage, with Canavirgella needlecast, caused by *Canavirgella banfieldii*, reported as a key component. Recently, however, the identity of *Canavirgella banfieldii* has been questioned, since there is evidence that it is really *Lophophacidium dooksii*, the fungus associated with Dooks needle blight—the two names are thought to be synonyms for the same fungal species. This was determined using morphologic, molecular, and phylogenetic analyses of samples collected from several locations in eastern Canada and the U.S. Therefore, Dooks needle blight is now considered to be the correct name for Canavirgella needlecast, since *L. dooksii* was described and published before *C. banfieldii*, and convention dictates the first name takes priority.

Dooks needle blight (formerly Canavirgella needlecast) was first diagnosed in Connecticut in 1998. The first report documenting *Canavirgella banfieldii* in the U.S. was published in 1996, and found to infect white pine throughout the eastern U.S. from North Carolina to Maine. Since then, the range and incidence of needle blight has expanded to Michigan and New Brunswick, Quebec, and Ontario, Canada.

Figure 1. Heavily infected young tree in spring. Note overall off-colored appearance and browning of one-year-old needles; lower branches are bare from cast needles.

SYMPTOMATOLOGY AND DISEASE CYCLE:

Dooks needle blight is a disease of *Pinus strobus* (Eastern white pine) and *Pinus peuce* (Macedonian white pine). The host range for this fungus has recently expanded to include western white pine (*Pinus monticola*) and Himalayan blue pine (*P. wallichiana*). Infected trees appear distinctly off-colored and brown from a distance in spring. Upon close inspection, symptoms are confined to last year's needles. The severity and prevalence of the disease have been associated with the cool, cloudy, wet spring and early summer weather that were suitable for spore formation, dispersal, and infection.

One of the diagnostic characteristics of Dooks needle blight is that not all needles within a fascicle are infected. Additionally, individual needles within a fascicle may exhibit differing amounts of symptomatic tissue (Figure 3). When needles are infected with *L. dooksii*, the bases of the symptomatic needles usually remain green and all five of the needles and the fascicle often remain attached to the tree. Symptomatic portions of individual needles may break off before the fascicles drop during periods of normal needle shedding. The general symptoms of this needle blight have frequently been confused with those associated with acute ozone injury, stress, and other needle blight diseases. However, with ozone, symptoms usually develop on all of the needles within a fascicle and all needles exhibit the same extent of injury.

Fruiting bodies (spermagonia) of *L. dooksii* begin to form under the epidermis on the stomatal (adaxial) surfaces of infected needles in late summer to winter. They appear as oval, blister-like, raised structures barely visible with a hand lens (Figure 4).

Figure 2. Diagnostic symptoms of Dooks needle blight. Note reddish-brown color of infected needles.

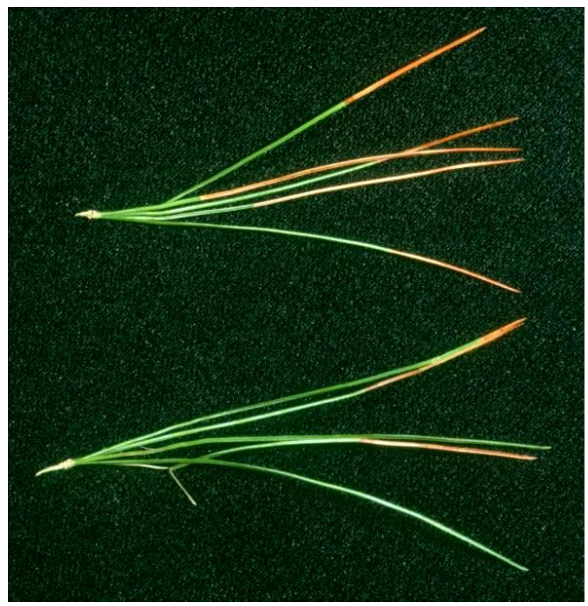

Figure 3. Individual needles in a fascicle show different levels of browning.

Additional fruiting bodies (called hysterothecia) develop on adaxial surfaces of symptomatic portions of the needles throughout the winter and spring. These structures first appear as dull gray stripes along the length of the symptomatic portion of the needle (Figure 5).

Figure 4. Developing fruiting body (spermagonium) of *L. dooksii*. Note oval shape of the raised, blister-like structure (arrow).

Figure 5. Dark gray stripes of developing fruiting bodies in spring.

Hysterothecia mature in late spring to early summer. Fruiting bodies can extend the entire length of an infected needle. These blacken as they mature—giving adaxial surfaces of infected needles distinctly raised black stripes (Figures 6, 7, and 8). These are visible with a hand lens or even the naked eye.

Each hysterothecium contains many asci or spore "sacs." Spores (ascospores) of the fungus develop and mature within each ascus. Mature asci usually contain eight ascospores. These spores are thought to be released during the early stages of needle elongation and during periods of favorable wet weather (Figures 9, 10, and 11).

Infection of succulent, elongating, current-season needles occurs in late June or early July. As with most needle blight pathogens, extended periods of free water on the needles are conducive for infection.

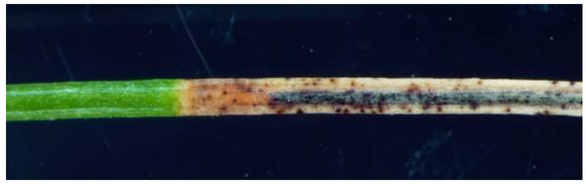

Figure 6. Developing fruiting body (black line) in infected portion of a needle.

Figure 7. Diagnostic blackened stripes on adaxial surfaces of infected needles.

Figure 8. Close-up of infected needles. Note black fruiting structures that develop in spring (arrows).

The disease does not appear to be site-specific, since heavily infected trees have been found on warm, exposed, south-facing slopes as well as on cool, moist, north-facing exposures.

Figure 9. Cross-section through an infected needle. Note fruiting body splitting through the epidermis on the adaxial surface of a needle (arrow).

Secondary fungi are often associated with infections by *L. dooksii*. Thus, the presence of these secondary organisms often creates problems with accurate diagnosis.

Not all white pines are susceptible to the disease, and it is believed that susceptibility may be hereditary. If this is the case, stands with related trees will show significant damage if susceptible, or relatively no damage if resistant.

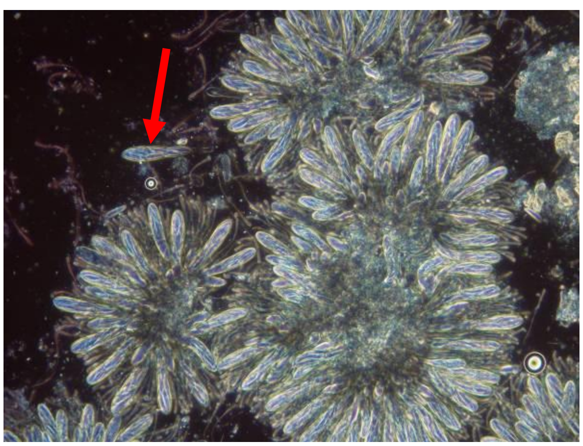

Figure 10. Microscopic view of many asci (arrow indicates spore sac(s)?) that contain ascospores.

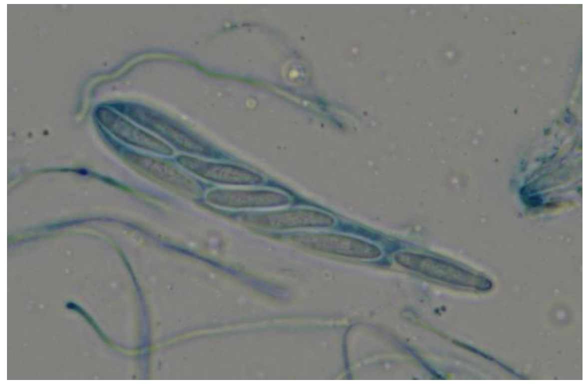

Figure 11. Each mature ascus (spore sac) usually contains eight spores (ascospores).

MANAGEMENT STRATEGIES:

As with most needle blights, Dooks needle blight rarely requires proactive management because it is usually considered more aesthetic rather than a life-threatening disease. However, there are situations when integrated, multifaceted management strategies might be necessary. These include following good sanitary and cultural practices. Tree vigor should be maintained by attention to watering, fertilizing (as determined by a soil test), and pruning. It is also helpful to avoid disturbing affected trees during periods of heavy symptom expression.

On the other hand, there are situations where recurring needle blights can be serious and cause permanent damage, disfigurement, or even tree death. Newly transplanted trees or trees weakened by environmental or site-related stress can be particularly sensitive to several years of repeated, premature needle drop. In such cases, chemical control may be beneficial, but is generally not suggested. However, once symptoms are visible on the needles, it is too late for chemical applications. Among the fungicides registered for homeowner use in Connecticut for managing Dooks needle blight are chlorothalonil, copper products, and mancozeb. The pesticide label will contain information on dosage rates, application intervals, and safety precautions. Since this fungus infects newly developing needles in spring to early summer, the first fungicide spray is applied as needles emerge. Additional applications at intervals stated on the fungicide label may be necessary under unusually wet or prolonged spring conditions until needles reach maturity.

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Dr. Sharon M. Douglas
The Connecticut Agricultural Experiment Station
Department of Plant Pathology and Ecology
123 Huntington Street, P.O. Box 1106
New Haven, CT 06504

E-mail: Sharon.Douglas@ct.gov
Phone: (203) 974-8601 or (203) 974-8496
Website: www.ct.gov/caes

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Dr. Sharon M. Douglas
Department of Plant Pathology and Ecology
The Connecticut Agricultural Experiment Station
123 Huntington Street, P. O. Box 1106
New Haven, CT 06504

Phone: (203) 974-8601
Fax: (203) 974-8502
Email: Sharon.Douglas@ct.gov
Website: www.ct.gov/caes

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DROUGHT, ITS AFTER-EFFECTS, AND MANAGEMENT STRATEGIES FOR WOODY ORNAMENTALS

Drought can impact many types of woody plants in landscapes, natural woodlots, and forests (Figure 1). It is a meteorological and environmental event defined as the absence of rainfall for a period of time long enough to deplete the soil of moisture and cause damage to plants. Under drought conditions, the water content of the soil is reduced to the extent that plants can no longer extract sufficient water to maintain life processes.

In defining what comprises a "drought year," the pattern and frequency of precipitation is more important than the total amount of precipitation recorded for the year. Total precipitation levels can be deceiving when interpreted solely on the basis of yearly amounts rather than on a month-by-month basis. This is because one or two significant precipitation events or storms in a year could account for much of the total precipitation recorded for that year. Therefore, it is the amount and frequency of precipitation rather than yearly totals that are important to the long-term health, growth, and vigor of woody plants. This is especially true during the growing season, when water demands are the greatest. Up-to-date information on precipitation levels recorded at the Experiment Station's Lockwood Farm is posted on the Station web site (http://www.ct.gov/caes).

Figure 1. Trees growing in thin soils along the top of a ridge show symptoms of drought in contrast to trees growing in deeper, organic soils.

To understand the impact of drought on woody plants, we need to understand the water relations in the plant. Without water, there is no plant life. Water is necessary for nearly all biological and biochemical processes within plant cells. For example, water is necessary for uptake and transport of mineral nutrients and transpiration drives the movement of water in the plant from the soil, to the roots, to the xylem, to the leaves, and to the air.

Drought causes primary and secondary physical damage as well as physiological changes in woody plants. The primary physical effect of drought or dry soil conditions is direct damage to the roots and root death. The root system of a woody plant has four types of roots: 1) framework roots consisting of primary and secondary woody roots, 2) transport and storage roots, 3) non-woody feeder roots, and 4) root hairs. The fine, multiple-branching, non-woody roots constitute the major proportion of the surface of the root system. Their primary function is to absorb water and minerals. Almost 99% of this root mass is in the top 12-18 inches of the soil. Unfortunately, non-woody roots and root hairs are the first parts of the root system to be affected by drought, since they are very sensitive to drying. When feeder roots and root hairs become nonfunctional, a water deficit develops in the plant because these roots can no longer provide sufficient water to the top of the plant.

In addition to direct physical damage to the root system, a significant secondary physical effect of drought is that it weakens plants and predisposes them to secondary invaders and opportunistic pests.

Drought also has physiological effects on plants. It triggers a cascade of metabolic changes in the physiology of the plant. A major drought effect is the reduction of photosynthesis. In part, this is associated with a decline in leaf expansion, impaired photosynthetic "machinery," and premature leaf senescence. Other effects are slowed or completely stopped growth, reduced ability to respond to wounds and compartmentalize, changed hormone levels associated with stomate function, and many others (e.g., factors that influence the number of leaves that are set and will emerge the next year).

SYMPTOMS:

Symptoms of drought are manifest in many different ways, depending on the plant species. These are also influenced by the severity and length of the drought, by the site, and by the vigor and vitality of the species. One important characteristic of drought is the fact that the symptoms are often not evident in the above-ground portion of the tree or shrub during or shortly after the drought, but may develop as much as one to two years later.

Drought symptoms include loss of turgor in needles and leaves, drooping, wilting, yellowing, and premature leaf or needle drop—symptoms that are often associated with moisture stress. Some atypical symptoms include bark cracks, and twig and branch dieback. Leaves on deciduous trees can develop a marginal scorch (Figure 2), interveinal necrosis, or a general browning (Figure 3). Needled evergreens can become chlorotic (Figures 4 and 5). Trees and shrubs can also exhibit general thinning of the canopy (Figure 6), poor growth, and stunting. In extreme cases, drought can result in plant death.

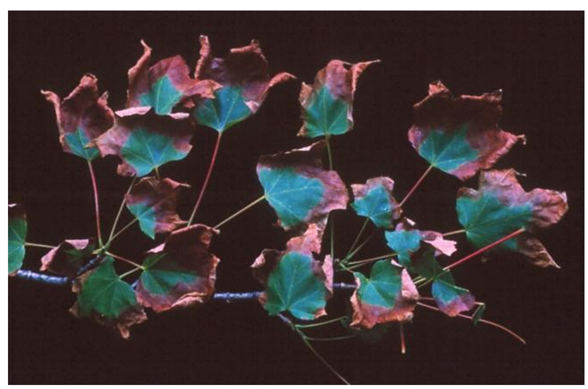

Figure 2. Typical marginal necrosis (scorch) of maple leaves associated with drought stress.

Figure 3. Browning of dogwood leaves associated with drought.

Figure 4. Hemlock with yellow (chlorotic) needles and tip dieback associated with drought.

Native plants growing naturally in woodlots or forested areas are usually adapted to regional and seasonal fluctuations in precipitation and only *unusually* severe drought conditions cause problems for them. However, planted landscape trees and shrubs often show symptoms of drought and severe water stress. Planting practices are frequently key sources of this problem, since trees and shrubs are often planted in unfavorable sites and the rootballs aren't properly prepared. They are also planted too deep or too shallow, or are mulched so

Figure 5. Spruce with chlorotic one-year needles (arrows) associated with loss of feeder roots from drought conditions the previous season.

thickly ("volcano mulched") that water cannot penetrate into the soil (Figure 6).

Symptoms of drought can develop on a wide range of deciduous and evergreen trees and shrubs and are particularly severe on seedlings and new transplants (Figure 8). This is because their roots occupy the uppermost layers of soil where the most rapid drying occurs. In addition, recent transplants typically lose important functional roots during the transplant process. For example, balled and burlapped trees are estimated to contain only 5% of their original root mass after digging.

For container-grown ornamentals, the medium in which the transplant is growing can be a key factor—many of the soilless mixes used for container stock are highly porous, dry out very quickly, and are very difficult to re-wet.

Figure 6. Thinning of the canopy of an established tree.

Figure 7. "Volcano" mulching of trees in a landscape.

This situation creates moisture stress in the root ball, regardless of the availability of water in the surrounding soil. This problem often continues until the roots grow beyond the root ball into the native soil. Contrary to popular opinion, it often takes woody transplants several years to become completely established in a new site. A rule of thumb is one year of recovery for each inch of trunk diameter. Thus, larger specimens require more time to recover from transplanting than smaller ones, so these plants should be given extra care and attention during periods of drought.

Figure 8. Death of a Christmas tree transplant (arrow) because of drought. Note that the established trees surrounding it have no symptoms.

Established trees and shrubs can also be affected by drought, especially those planted in marginal sites such as those with pavement over their roots, street trees, and those in pockets of soil on ledges or in sandy soils. Problems have also been observed on apparently established trees and shrubs that have survived despite improper planting and have root defects that haven't been addressed such as girdling or circling roots. Once stressed by drought, these trees quickly decline and often die.

Since drought also weakens and predisposes plants to secondary invaders and opportunistic pests, a variety of diseases can be identified on these compromised plants. These include tip blights, vascular wilts, root rots, and needlecasts. Among the key secondary problems are:

Winter Injury: Drought-stressed woody ornamentals are not as winter-hardy as their healthy counterparts.

Root Problems: Injured or weakened root systems are more susceptible to root rots.
<u>Example:</u>

- Armillaria Root Rot
  - Causal Agent: *Armillaria* species complex
  - Hosts: many species including pine, fir, oak, maple

Cankers: Weakened woody ornamentals have slowed "defenses" and wound healing is inhibited.
<u>Examples:</u>

- Bleeding Canker
  - Causal Agent: *Phytophthora* spp.
  - Hosts: many species, esp. beech
- Botryosphaeria Canker
  - Causal Agent: *Botryosphaeria* spp.
  - Hosts: many species, oak, maple, crabapple, rhododendron
- Cytospora Canker
  - Causal Agent: *Leucostoma kunzei*
  - Hosts: spruce, esp. blue spruce
- Hypoxylon Canker
  - Causal Agent: *Hypoxylon* spp.
  - Hosts: many species, oak
- Nectria Canker
  - Causal Agent: *Nectria* spp.
  - Hosts: many species, maple, birch

Wood Rots: Associated with slowed defenses because of limited ability to compartmentalize and react to invasion by wood-rotting fungi.
<u>Examples:</u>

- Fomitopsis on red spruce
- Ganoderma on oak, maple, and most hardwoods

Sensitivity to Pesticides: Weakened woody ornamentals are more sensitive to pesticides, including compounds that normally do not cause problems for healthy plants. Phytotoxicity of drought-stressed plants results from increased sensitivity to many herbicides, insecticides, and fungicides.

Sensitivity to De-icing Salts: Weakened woody ornamentals are more sensitive to de-icing salts, especially sodium chloride.

Miscellaneous Diseases: An increase in the frequency and severity of several diseases has been associated with drought stress.
<u>Examples:</u>

- Ash Yellows
  - Causal Agent: Phytoplasma
  - Hosts: ash, especially white and green ash
- Diplodia Blight
  - Causal Agent: *Diplodia pinea*
  - Hosts: many conifers include Douglas-fir, spruce and pine, esp. two- and three-needled pine
- Dutch Elm Disease
  - Causal Agent: *Ophiostoma novo-ulmi*
  - Hosts: elm
- Elm Yellows
  - Causal Agent: Phytoplasma
  - Hosts: elm
- Rhizosphaera Needlecast
  - Causal Agent: *Rhizosphaera kalkhoffii*
  - Hosts: spruce, esp. blue spruce
- Verticillium Wilt
  - Causal Agent: *Verticillium* spp.
  - Hosts: many woody plants, esp. Japanese maple, redbud, and smoke tree

STRATEGIES FOR MANAGING DROUGHT:

While there is no “cure” for this problem, the effects of drought can be minimized by following some preventative measures:

1. Water in periods of low soil moisture--
Trees and shrubs require approximately one inch of water per week. Special attention to young trees is important. For most soil types, water is best applied at one time as a slow, deep soaking of the entire root zone to a depth of approximately 12-18 inches. The length of time required to “deep-water” will vary depending on soil type and water pressure; clay soils usually require more time than sandy soils. Frequent, light, surface watering will ***not*** help the tree and can actually cause harm by promoting growth of non-woody surface roots. A deep soaking just before the ground freezes in the fall will also help the winter hardiness of drought-stressed plants.

2. Select the appropriate site and follow good planting practices--
Drought stress can magnify even the most subtle improper planting practices (e.g., planting too deep or too shallow, failure to remove or cut the burlap and/or the wire basket). When planting a tree, try to anticipate the soil volume and water needs of the tree at maturity.

3. Select native plants or match plant species to site conditions--
Drought-sensitive (e.g., dogwood, some oaks, ash, birch) *vs.* drought-tolerant (e.g., most pines, junipers, many *Prunus*, larch).

4. Mulch to maintain soil moisture--
Properly applied organic mulches can be very helpful for retention of soil moisture. Mulches are usually applied 1-3 inches thick and spread evenly out to the drip line of the tree. It is also important to keep the mulch 6-12 inches away from the trunk. Mulches that are applied too thickly (“volcano” or “pyramid” mulches) or too close to the base of the tree can be harmful.

5. Prune any dead or weakened tissues to avoid secondary problems--
Removal of weak or damaged branches can eliminate entry points for secondary insects and diseases. Pruning of diseased branches also prevents infections from spreading to other parts of the tree and to the main trunk.

6. Maintain plant vigor by following good cultural practices--
It is generally accepted that trees under stress should not be fertilized. However, applications of biostimulants, mycorrhizae, or similar compounds have occasionally been reported to stimulating root growth and regeneration.

April 2011 (revised)

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FACT SHEET

EXCESS WATER PROBLEMS ON WOODY ORNAMENTALS

Dr. Sharon M. Douglas
Department of Plant Pathology and Ecology
The Connecticut Agricultural Experiment Station

Flooding, excess water, and poorly drained soils can be serious problems for many woody ornamentals. These may result in plant decline and death as well as uprooting of trees. Roots in flooded or waterlogged soils are damaged and die from oxygen deficiency, which inhibits normal respiration in the roots. This leads to sharp increases in the levels of carbon dioxide, methane, hydrogen, and nitrogen gas around the roots, causing them to suffocate and die. Additionally, toxic compounds, such as ethanol, hydrogen sulfide, and other harmful compounds often build up in saturated soils.

In addition to direct damage to the root system, flooding can incite a cascade of physiological changes in woody plants that influence growth and many other biological processes. For example, photosynthesis may be inhibited and growth may slow or stop. Flooding can also initiate changes in levels of growth regulators in a plant—increasing concentrations of auxin, ethylene, and abscisic acid, and decreasing concentrations of gibberellic acids and cytokinins. Even when standing water is not present, poorly drained soils can reduce plant growth and long–term survival in the landscape due to chronic low oxygen levels in the soil.

Tolerance to flooding depends on many factors, including plant species and general vigor, site and soil conditions, time of year, and extent or duration of flooding and water quality (Figure 1). Some plants may recover from flooding injury in one season, whereas others do not recover at all. Many popular landscape woody ornamentals are among the most sensitive species to flooding. These include Norway and sugar maple, beech, northern red and white oak, yellowwood,

Figure 1. Mature trees in standing water after a storm.

cherry, plum, eastern redbud, crabapple, lilac, rhododendron, privet, cotoneaster, euonymus, weigela, and evergreen species such as pine, Norway and Colorado blue spruce, hemlock, eastern red-cedar, and yew (Figure 2).

Figure 2. Dead yews growing in low area prone to recurring flooding after heavy rain events.

Woody plants have two basic types of roots—woody and non-woody. Woody roots are generally more tolerant to flooding than non-woody roots. Non-woody roots, also called feeder roots, comprise the majority of plant roots. These roots are responsible for uptake of water and dissolved nutrients in the soil. They are sensitive and are frequently the first ones damaged by waterlogging. When non-woody roots are damaged, they are unable to provide water to the top of the plant and a water deficit develops. Non-woody roots are fairly short-lived and last a few weeks to a year. As a result, they are continually being produced by the plant—although under waterlogged conditions, this process is disrupted so the plant has insufficient absorptive roots to meet its needs.

Damage to non-woody roots can be sudden or gradual, depending upon the plant species and the flooding conditions. This can occur on plants in obviously wet sites and those in marginal sites or soils with more subtle water problems, such as along city streets or in areas where high clay content and compaction in the soil impede drainage. Most trees and woody shrubs cannot grow in waterlogged soils for very long and can die if flooded for only a few days during the growing season. Visible symptoms are *often* not evident until considerably after the damage has occurred, especially when the root damage is gradual.

SYMPTOMS:

Symptoms of excess water depend upon the plant species and are highly variable. These include epinasty or downward rolling of leaves, stem swelling, chlorosis or yellowing of the foliage, reduced and stunted growth, twig dieback, leaf drop, early fall color, root death, and in some cases, plant death. Oedema can also develop on leaves of some species (Figure 3).

Figure 3. Oedema visible on upper (top photo) and lower (bottom photo) surfaces of rhododendron leaves after growing in waterlogged soils.

Seedlings and new transplants are more sensitive to excess water problems than established plants. This can be attributed to the lack of an established root system and to damage to the non-woody roots during the transplant process. Needled evergreens are generally considered more sensitive to waterlogged soils than broadleaved, deciduous plants (Figure 4).

Figure 4. Fraser fir transplants with off-colored needles after growing in poorly drained soil for two years.

Symptoms of waterlogging may not develop in a woody ornamental until water demands on the root system increase, typically during the hot summer months when the canopy is actively losing water through transpiration. This is sometimes exhibited as a sudden collapse of the tree or shrub. Other trees appear to lose vigor and slowly decline over a period of years. This can occur on trees that have been otherwise "healthy" for 10-15 years, but are growing in poor sites or heavy soils. Dormant plants generally appear to tolerate flooding longer than those in active growth.

Trees with substantial root damage from flooding or saturated soils can begin to lean and are prone to uprooting or "windthrow" (Figure 5). These should be monitored and removed once they become hazardous.

In addition to direct root damage, woody ornamentals stressed by waterlogging become much more susceptible to some soil-borne pathogens. In particular, root and crown rots associated with *Phytophthora*, *Fusarium,* and *Rhizoctonia* species can occur with greater frequency on plants routinely exposed to excess water (Figure 6).

Figure 5. Tree uprooted after period of standing water and saturated soil.

Figure 6. Fraser fir with Phytophthora root rot exhibiting diagnostic discoloration of the cambium at the root/crown area.

MANAGEMENT AND REMEDIATION STRATEGIES:

Although the weather cannot be manipulated and there are no "cures" for plants permanently affected by excess water once the damage is done, there are strategies that can help to minimize the occurrence of this issue.

- Select a well-drained site and avoid planting in chronically flooded areas. Rework or modify the site by planting on raised beds or berms, or by installing drain tiles to direct water away from the root zone.
- Use sound planting and cultural practices to maintain overall plant vigor. Avoid fertilizing for at least a year following a flood because of root injury.
- Select appropriate species for soil and site conditions: water-tolerant (e.g., red maple, larch, green ash) *vs.* water-intolerant (e.g., crabapple, spruce, hemlock, yew, white pine).
- Aerate the soil around the tree or shrub to reduce compaction associated with wet or waterlogged soil. Apply organic mulch (such as shredded bark) to help remediate or improve soil structure.
- Prune and remove any dead twigs or branches, since they can serve as sites for secondary invaders or opportunistic pests.
- Monitor plants for symptoms of decline over the next few years.

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Dr. Sharon M. Douglas
The Connecticut Agricultural Experiment Station
Department of Plant Pathology and Ecology
123 Huntington Street, P.O. Box 1106
New Haven, CT 06504

E-mail: Sharon.Douglas@ct.gov
Phone: (203) 974-8601 or
(203) 974-8496
Website: www.ct.gov/caes

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Dr. Sharon M. Douglas
Department of Plant Pathology and Ecology
The Connecticut Agricultural Experiment Station
123 Huntington Street, P. O. Box 1106
New Haven, CT 06504

Phone: (203) 974-8601
Fax: (203) 974-8502
Email: Sharon.Douglas@ct.gov
Website: www.ct.gov/caes

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FIFTY YEARS OF CONNECTICUT CHRISTMAS TREES: A PLANT PATHOLOGIST'S PERSPECTIVE

During the last fifty years, many changes have occurred in the types of conifers grown as Christmas trees in Connecticut and in consumer preferences for particular tree species. These changes have led to modifications in growing practices to continue production of attractive, marketable trees. When asked to prepare a review of diseases on Christmas trees during this fifty year period, I started by examining The Connecticut Agricultural Experiment Station's *Record of the Year* back to 1960 for reports on diseases. This seemed a good source, since the Connecticut Christmas Tree Growers Association (CCTGA) and the Experiment Station have maintained a relationship of mutual support over the years. As part of this relationship, Station scientists assist Christmas tree growers on issues from tree selection and culture, to weed, insect, and disease management, and growers provide trees, land, and assistance with Station experiments. Looking through the records, I noted that there were very few disease reports until the early 1980's. This surprised me, since I have seen growers challenged by a number of different diseases during my 28 years at the Station.

Was there a reason why diseases were not reported in the early years? What was different about 1960 when compared to 2010? A good start to answering these questions is to consider the types of conifers grown for Christmas trees and the changes that have occurred over the years. Spruces, particularly white and Norway spruce, comprised the dominant species grown in the state until the 1970's. These trees were, and continue to be, relatively problem-free, so quality issues associated with diseases were likely not a concern for most growers. However, once blue spruce entered the picture and more acres were planted to this species, disease became a recurring concern for growers--blue spruce is more susceptible than other spruces to diseases such as repeating spruce needle rust and Rhizosphaera needlecast.

Along with blue spruce's popularity was a rise in the popularity of Douglas-fir, and increased acreages of it were planted throughout the state. The Lincoln strain of this species was popular because of its form and rate of growth, despite being highly susceptible to Rhabdocline needlecast (Figure 1). In fact, the first mention of diseases on conifers that appeared in the Station's *Record of the Year,* was a report on Rhabdocline in 1980. By 1983, this disease was reported to have dramatically increased throughout the state.

Figure 1. Rhabdocline needlecast of Douglas-fir.

In addition to changes in tree species, other factors influencing the prevalence of diseases were: 1) changes in consumer and market demands and 2) increasing competition between real Christmas trees and artificial trees. Christmas tree growers made adjustments to meet these new expectations by looking for species with superior post-harvest needle and moisture retention characteristics. Savvy consumers began to demand trees with long needle retention, perfect shape, and unblemished needles. This resulted in tremendous increases in plantings of Fraser fir. This species is considered by many to be the world's best Christmas tree because of its wonderful fragrance, soft needles, and strong branches. Connecticut growers learned how to grow this desirable species, but also learned that they had to deal with its high susceptibility to Phytophthora root rot.

As demands from consumers and wholesalers increased, Connecticut choose and cut growers and wholesale growers began to explore exotic tree species to increase the variety and quality of trees that they offered. The introduction of many of these species into the state led to issues associated with hardiness and increased vulnerability to stress-related diseases such as Rhizosphaera needlecast and Armillaria root rot. Other diseases problematic to these new tree hosts started to appear, such Uredinopsis needle rust of concolor fir (and occasionally grand, balsam and Fraser fir) and current season needle necrosis of grand fir.

Environmental and cultural issues also contributed to the prevalence and severity of diseases on many species—with Diplodia blight and Armillaria problematic after drought, and Phytophthora root rot associated with poorly drained soils and excess rainfall. In addition to these biotic diseases, abiotic conditions like the extended rainy weather of the last two years affected tree growth and vigor, and the ability of trees to withstand the challenges of plant pathogens.

Over the years, new diseases continued to appear and in 1998, Canavirgella needlecast was first diagnosed on white pine in Connecticut. This followed the first report of this disease in the U.S. published from Pennsylvania in 1996. In 2009 and 2010, Canavirgella needlecast was widespread on white pines in plantations and landscapes throughout the state (Figure 2).

Figure 2. Canavirgella needlecast of white pine in 2010.

Today, the major types of trees commonly available in Connecticut are true fir (Fraser, Canaan, concolor, and balsam), Douglas-fir, spruce (white, blue, and Norway), and Eastern white pine (Table 1). There are also a number of other species (e.g., Nordemann spruce, Meyer spruce, grand fir, Nikko fir, Turkish fir), but these are usually being grown in smaller quantities or on a trial basis.

Table 1. Major tree species and common diseases in Connecticut.

Tree Species	**Common Diseases**
True firs (Fraser, concolor, balsam)	• Phytophthora root rot
Spruce (blue, white)	• Armillaria root rot • Repeating needle rust • Rhizosphaera needlecast
Douglas-fir	• Diplodia blight • Rhabdocline needlecast
White pine	• Canavirgella needlecast • Diplodia blight
All species	• Armillaria root rot • Diplodia blight • Phytophthora root rot

As follows are brief descriptions of key diseases of Christmas trees in the state, with ratings on the potential for damage and outbreaks to occur. This list is not all-inclusive, since there are many other diseases present in the state.

NEEDLE DISEASES

Needle diseases present the most consistent threat to quality loss because of their ability to increase under environmental conditions conducive to infection, mainly rainfall, especially as new growth is emerging in spring. These diseases are most serious within 2-3 years of anticipated harvest.

RHABDOCLINE NEEDLECAST

1. **Causal Agent:** *Rhabdocline* spp. (fungi)
2. **Key Host:** Douglas-fir
3. **Outbreak and Damage Potential:** High
4. **Brief Description:**

Rhabdocline needlecast is the most common disease of Douglas-fir in Connecticut. It was first reported in the 1920's and has increased in incidence and severity over the years. This increase can be attributed to factors that include weather, widespread plantings of susceptible seed sources of Douglas-fir such as Lincoln in plantations and landscapes, and environmental stress. The primary damage is defoliation, which leads to suppressed growth, occasional deformity, and value loss in Christmas trees.

RHIZOSPHAERA NEEDLECAST

1. **Causal Agent:** *Rhizosphaera kalkhoffii* (fungus)
2. **Key Hosts:** blue spruce, occasionally white spruce (Douglas-fir, true fir, and pine have been reported as hosts)
3. **Outbreak and Damage Potential:** Moderate
4. **Brief Description:**

This needle cast fungus causes recurring damage on blue spruce throughout Connecticut, especially on trees under drought stress. Although trees can be killed, the primary damage is premature needlecast. Under epidemic conditions, lower branches may be killed. The fungus attacks needles on the lower branches first and gradually progresses up the tree. Early defoliation leads to suppressed growth, occasional deformity, and reduced marketability.

CANAVIRGELLA NEEDLECAST OF WHITE PINE

1. **Causal Agent:** *Canavirgella banfieldii* (fungus)
2. **Key Hosts:** Eastern white pine
3. **Outbreak and Damage Potential:** Moderate

4. **Brief Description:**
   This needlecast was first identified in Connecticut in 1998, but was widespread in 2009 and 2010. Infected trees appear distinctly off-colored and brown from a distance in spring. Symptoms develop on one-year-old needles. Although infected trees are rarely killed, the damage results in extensive needle discoloration and drop, which reduces the marketability of the infected trees. Last year's extended periods of free water on the needles was highly favorable for infection.

AUTOECIOUS (REPEATING) SPRUCE NEEDLE RUST

1. **Causal Agent:** *Chrysomyxa weirii* (fungus)
2. **Key Hosts:** blue (and occasionally white spruce)
3. **Outbreak and Damage Potential:** High
4. **Brief Description:**

This disease is considered to be a relatively new problem for Connecticut, since it was first reported with any severity and frequency in 1996. However, it has probably been present in the state prior to 1996. This is an autoecious rust that does not require any additional hosts in order to complete its life cycle. Infected trees are rarely killed, but damage results in extensive needle discoloration and drop that reduces the marketability of infected trees, especially when it occurs shortly before harvest.

TIP AND SHOOT BLIGHTS

Tip and shoot blights can be occasional problems, but they can result in severe damage. In addition, they are usually very difficult to manage, especially on trees under stress.

DIPLODIA BLIGHT

1. **Causal Agent:** *Diplodia pinea* (fungus)
2. **Key Hosts:** Douglas-fir, white pine, and blue, Norway, and white spruce
3. **Outbreak and Damage Potential:** High
4. **Brief Description:**

Diplodia blight can be a destructive and devastating disease of conifers, especially when growing under conditions of stress, particularly drought stress. This fungus has a broad host range and widespread distribution, so sources of inoculum are common. Although it is a pathogen, the fungus can also survive as a saprophyte. Therefore, it can be present on trees for many years without causing symptoms. In cases where disease is severe, shoots can be blighted and trees deformed. Repeated infections can kill weak trees.

ROOT DISEASES

Roots diseases are probably the most difficult diseases that growers encounter. If left unchecked, they usually result in tree death. Diagnosis can be difficult and management is challenging because the causal agents can survive for many years in the soil.

ARMILLARIA ROOT ROT

1. **Causal Agent:** *Armillaria spp.* (fungi, complex of species)
2. **Key Hosts:** all types of conifers, as well as hundreds of other woody plants
3. **Outbreak and Damage Potential:** Moderate, depending on drought stress
4. **Brief Description:**

This disease is also known as shoestring root rot and honey mushroom root rot, and is one of the most common and potentially damaging diseases of forest, plantation, shade, and ornamental trees worldwide. Part of this destructive potential is the ability of the fungus to live for many years in decaying wood in the soil. The fungus can also take advantage of weakened or stressed trees, particularly trees under drought-stress, growing on shallow or "boney" sites. Trees with J-roots are highly susceptible. Patterns of damage within a plantation are often focused around old tree stump so diseased trees often occur in groups. Once infected, trees eventually die.

PHYTOPHTHORA ROOT ROT

1. **Causal Agent:** *Phytophthora* spp. (fungus-like organism)
2. **Key Hosts:** most conifers, especially true firs such as Fraser fir
3. **Outbreak and Damage Potential:** Moderate to High (depending on rainfall, soil type, and drainage)
4. **Brief Description:**

This disease has become a widespread and serious problem in the past 20 years, and can be correlated with the increasing number of susceptible trees, particularly highly susceptible Fraser firs, grown in the state. It is often associated with drainage problems and wet sites and can develop after 2-3 rotations (crops) of susceptible species grown in the same field. This soil borne pathogen (previously called a "water mold") produces motile spores that readily move in water. Aboveground symptoms include suppressed growth, poor vigor, yellowed or undersized needles, premature needle drop, branch dieback, wilt, and death of trees at any time during the season. This disease can occur in plantations and in seedling and transplant beds.

CONCLUSIONS

Many of the challenges that Christmas tree growers face today are similar to the ones they faced in 1960. Diseases associated with the most popular trees species, which are currently Douglas-fir and true firs, continue to be troublesome. As new tree species are introduced into the state, new diseases will continue to appear.

An important additional challenge is managing these diseases, which relies on a limited number of fungicides that are labeled, cost-effective, and efficacious for Christmas trees. Today, chlorothalonil is the most effective and widely used fungicide in Connecticut Christmas tree plantations, seconded by mancozeb, and then by thiophanate methyl. Widespread use and reliance on such a limited number of fungicides has the potential to cause the development of fungicide resistance, which to my knowledge, has not been found yet in Connecticut. For some root rot diseases (Armillaria) fungicides are not effective, whereas for others (Phytophthora) they have limited efficacy and are very expensive.

Looking at the next fifty years of managing diseases in plantations, I see a need for continued research to identify or develop consistent sources of disease-resistant planting stock with desirable aesthetic qualities in order to make disease management more eco-friendly and cost-effective.

[I would like to thank Tom Rathier for insightful discussions on this topic.]

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Dr. Sharon M. Douglas
Department of Plant Pathology and Ecology
The Connecticut Agricultural Experiment Station
123 Huntington Street, P. O. Box 1106
New Haven, CT 06504

Phone: (203) 974-8601
Fax: (203) 974-8502
Email: Sharon.Douglas@po.state.ct.us

FIRE BLIGHT

Fire blight is probably the most devastating bacterial disease of apples, pears, and many other rosaceous plants grown in North America. While outbreaks are sporadic in occurrence, they often result in significant losses when they occur, whether measured by loss of trees or loss of dollars. In 2000 and 2001, several Connecticut orchards were affected by fire blight and disease outbreaks were also reported throughout New England and New York. The severity of Connecticut outbreaks in 2001 could be partly attributed to the unusual weather conditions in spring which included a heat wave during bloom followed immediately by frost. Michigan also experienced severe fire blight problems during 2000 and reported a $42 million total economic loss for the region that resulted in the removal of 350,000-450,000 apple trees covering approximately 1,550-2,300 acres. The 2000 outbreak followed a previous Michigan outbreak in 1991 which resulted in losses of over $3.8 million. In 1998, fire blight outbreaks were reported in Washington and northern Oregon in which apple and pear growers reported losses of over $68 million.

Although fire blight is erratic in occurrence, there is a trend for more frequent and more devastating outbreaks that can be attributed to several factors associated with current orchard management practices and market demand. Four key changes over the last decade have increased our vulnerability to fire blight. These are briefly summarized as follows:

- **Orchard density:** instead of planting 100-200 apple trees/acre, we now plant up to 10 times that density with 250-1,500 trees/acre;
- **Tree size:** in order to accomplish high tree densities, it is necessary to use size-controlling rootstocks; M.9 and M.26 are two of the most commonly used rootstocks; they are also highly susceptible to fire blight;
- **Varieties:** many of the new varieties that meet the demands of the fresh fruit market (e.g., Gala, Fuji, Gingergold, Jonagold, Braeburn) are also highly susceptible to fire blight; the combination of susceptible varieties on susceptible rootstocks further complicates the susceptibility problem;
- **Training systems:** new training systems used to make high density plantings more productive push trees immediately into strong vegetative growth and force early production.

HISTORY

Fire blight is considered to be a disease of American origin and was known in this country for many years before it was reported in the Hudson Valley of New York in 1794. By the 1900s, fire blight had spread to most areas where pears and apples were grown in the U.S. and was associated with many outbreaks and epidemics. Fire blight now occurs worldwide and is found in many of the important countries for pome fruit production.

CAUSAL AGENT

Fire blight is caused by the bacterium *Erwinia amylovora.* This organism is readily spread by wind, splashing rain, insects, and human activities. Although this bacterium is considered a plant pathogen, it is also a competent epiphyte which can grow and multiply on plant surfaces, regardless of whether the plant is resistant or susceptible to fire blight. At moderately warm temperatures (65-75°F), it has been estimated that the bacterium can double every 20-30 minutes. Strains of the fire blight bacterium with resistance to streptomycin have been reported in the eastern U.S. but are widespread in most apple and pear regions of the western U.S.

HOSTS

- **Primary Economic Hosts:** pome fruits, including apple, pear, and quince; varieties and rootstocks differ in susceptibility to fire blight (Tables 1 and 2)
- **Ornamental Hosts:** many members of the Rosaceae family including crabapple, hawthorn, mountain ash, pyracantha, and cotoneaster

INFECTION TYPES OR PHASES

There are five different types or phases of infections that can occur during a fire blight outbreak. However, not all infection types occur during every outbreak of the disease. The infection types are canker, blossom, shoot, trauma, and rootstock blight. These types differ in the sources of inoculum, types of tissues that are infected, and the weather conditions that influence the infection process. The symptoms associated with each infection type can be quite distinct but once an epidemic is underway, they become increasingly difficult to differentiate. Since the same control strategies don't work for all infection types, it is important to be able to recognize the infection type in order to select the appropriate control measure.

A. Canker Blight:

Symptoms: Overwintering cankers are often clearly defined and appear as slightly to deeply depressed areas of discolored bark on trunks and large limbs. These cankers are usually easy to recognize and occasionally develop cracks at the margins. Many much smaller cankers are also often present on the trees but are not very easy to recognize. These small cankers are believed to provide a *major source of inoculum* in spring and are found on small twigs or limbs where infections had occurred the previous year. Since the cankers are relatively young, they can be less than one inch in diameter and are usually not particularly sunken and are rarely cracked. Cankers are often focused on a branch stub or fruit spur and when outer bark is cut away, inner tissues are water-soaked with reddish streaks. Overwintering cankers can also produce wilted shoots which are often confused with the shoot blight phase of disease. This symptom develops as bacteria move from overwintering cankers into nearby shoots. Infected shoots have a yellow-orange discoloration of the tip bud and stem which helps to distinguish them from shoot blight phase symptoms. In spring, bacterial ooze can appear on canker surfaces or margins during wet weather. This ooze is attractive to many insects (flies, in particular) which feed on the ooze and then move to the nectaries of flowers in nearby trees and transfer the bacteria to the surfaces of flower parts. It has been estimated that one active, overwintering canker can produce enough bacteria to severely contaminate flower blossoms on trees in an area consisting of ¼-½ acre.

Importance: This infection type is the primary source of inoculum and renewed infectious activity of the bacteria in the spring. Overwintering cankers are responsible for spread of disease into adjacent flowers, shoots, and growing tips. This phase of disease is always present if fire blight was a problem the previous season.

B. Blossom Blight:

Symptoms: Symptoms of this phase of fire blight usually appear within one to two weeks after bloom although they can develop as late as one month after infection if temperatures are cool. Blossoms first appear water-soaked and the sepals and whole blossoms blacken. Infected blossoms often adhere to the cluster base. Infection of a single flower in a cluster of five usually kills the entire spur. Bacterial ooze can develop under wet conditions and the bacteria are readily spread by pollinating insects. Symptoms can develop on infected fruit and can differ in appearance depending upon when the fruit were infected. Bacterial ooze can develop on fruit surfaces during wet weather.

Conditions for Blossom Infection: Blossom blight may or may not occur in any given season and varies in its incidence and severity with the number of open flowers colonized by the bacteria, temperature, and wetting events. Flowers must be open (full bloom) and colonized by the bacteria. They are subject to infection within minutes after any wetting event (e.g., heavy dew, rain) when the average daily temperatures are equal to or greater than 60°F. Wetting events also include high volume sprays or overhead irrigation applied during bloom. Relative risk levels can be predicted using predictive models such as Maryblyt® developed by Dr. Paul Steiner, University of Maryland, and Cougarblight developed by Dr. Timothy Smith, Washington State University.

Importance: This phase of disease is critical for the development of fire blight epidemics. Once the bacteria have successfully infected the blossoms, they are readily spread throughout the orchard by pollinating insects.

C. Shoot Blight:

Symptoms: Shoot blight symptoms are also called “blight strikes” and develop on actively growing vegetative shoots. They can be associated with, but not limited to, insect feeding or damage. Disease occurrence has also been associated with modest wind damage to tender young shoots. Infected shoots first appear slightly wilted and develop the diagnostic “shepherd's crook” typical of fire blight. Leaves on these shoots first show dark streaks along the midveins and then wilt and brown. Entire shoots blacken and develop the diagnostic “burned” appearance as the bacteria move progressively down the shoot.

Importance: This phase is especially destructive to young, vigorous trees. On highly susceptible varieties, infections move rapidly and can invade large supporting limbs. Depending upon the cultivar and stage of development, a single shoot infection can result in the death of an entire limb, or if the central leader of a main trunk is involved, a tree can be lost in a single season. In general, shoot infections that occur between petal fall and terminal bud set usually lead to the greatest limb and tree losses.

D. Trauma Blight:

Symptoms: Symptoms are similar to shoot blight but are usually more random and widespread throughout the orchard. This phase of fire blight is associated with a traumatic event such as hail, frost, or severe wind. Although mature shoots and limbs are generally resistant to infection, these traumatic events cause wounds which allow the bacteria to directly penetrate the tissues and bypass normal defenses. Since the bacteria are usually already present on the tissues as epiphytes, all they need are wounds and moisture in order to infect.

Importance: Infection is not limited to susceptible varieties since the physical damage of the trauma destroys natural defense mechanisms in the tree. The amount of trauma blight is usually associated with the amount of epiphytic colonization in the orchard since this phase of disease requires bacteria to already be present in the orchard.

E. Rootstock Blight:

Symptoms: The primary way rootstocks are infected is now known to be through internal means, often through apparently healthy limbs and trunks of trees that had only a few blossom infections or shoot strikes. Rootstock blight can develop in four phases: 1) oozing of bacterial masses from the rootstock within 2-4 weeks after symptoms appear in the canopy; 2) rapid collapse and death of a tree in late June to late July; 3) development of early fall red color in the canopy of a tree in late August and early September; and 4) early decline and death of a tree the spring following infection; during this phase infected rootstocks often have active cankers that extend towards the scion. Rootstock blight is common on highly susceptible M.9 and M.26 rootstocks. Research has demonstrated that on very young trees, low numbers of bacteria can move from infections in the upper tree, down through the trunk, and into the rootstock in approximately 21 days.

Importance: Once the bacteria enter a susceptible rootstock, they form new cankers that can completely girdle and kill the tree in one to several months. Although not all trees with fire blight symptoms in the scion develop rootstock blight, the susceptibility of the rootstock is a key factor. Although many trees with rootstock infections may have "reasonable looking" canopies, most will not survive into the next season. Rootstock infections on trees during their first 3 years are most devastating.

STRATEGIES FOR MANAGEMENT OF FIRE BLIGHT

Because of the inoculum potential and the ability of new inoculum to be repeatedly dispersed throughout an orchard by wind, splashing rain, and insects, it has been said that ***There is no such thing as a "little bit" of fire blight*** when dealing with this disease. Therefore, it is important to follow an aggressive program that addresses ALL infections, regardless of their apparent significance, location on the tree, or time of year.

1. Removing Primary Sources of Inoculum:

- **Dormant pruning-** Since the bacteria overwinter in living tissues at the margins of cankers, pruning during the dormant season will remove a significant amount of primary inoculum. A thorough pruning is necessary in order to remove as many of the infections as possible. It is especially critical to recognize and remove the small, young cankers. Whole trees or large branches should be removed from the orchard during dormant pruning. Small branches can be raked into row centers and mulched with a flail mower.
- **Early season inspection and pruning-** It is helpful to inspect the orchard for any overwintering cankers that may have been overlooked during dormant pruning. Many of

the small cankers that went unnoticed during previous pruning efforts become more visible once they start to ooze bacteria. These inspections usually begin around green tip.

2. Monitoring Weather Factors in the Orchard:

- Because of the importance of weather to fire blight, it is helpful to monitor the orchard for temperature and rainfall. A weather station that records the daily minimum and maximum temperatures and rainfall amounts is necessary. Information from leaf wetness meters is also helpful for the predictive models.
- **Predictive Models-** Weather information is critical for predictive models such as Maryblyt® or Cougarblight. It is used to identify potential infection periods and to improve the timing of antibiotic sprays.

3. Bactericide Control:

- **Copper sprays**- Copper sprays *do not* kill bacteria within overwintering cankers but are used to reduce the ability of the fire blight bacteria to colonize bark and bud surfaces during the early pre-bloom period. Because of this mode of action, critical timing and thorough spray coverage are important. The first applications are made at green tip since that coincides with the period when the bacteria are growing and becoming available for infection. It is very important to spray ALL trees within the block, regardless of their susceptibility to fire blight since the bacteria are spread at random within the block and can colonize all tissues as epiphytes. These serve as important additional sources of inoculum. The benefits of copper sprays during the season are questionable and have yielded inconsistent results. Additionally, these sprays can be highly phytotoxic to fruit.
- **Streptomycin sprays-** Prevention of blossom infections is a critical aspect of a disease management program. Streptomycin is bactericidal so it kills the bacteria. At bloom, antibiotic sprays are highly effective against the blossom blight phase of disease. Predictive models such as Maryblyt® and Cougarblight help to identify potential infection events so antibiotic sprays can be applied to protect the tissues from infection. Timing of these sprays is critical to control since this antibiotic is only active for 3 days after application. Streptomycin sprays have been found to be ineffective for prevention and control of shoot blight infections. However, they can be helpful to control trauma blight associated with wind damage and hailstorms *if* applied immediately (within 12-18 hours) after the weather event. Since resistance to streptomycin has been documented in many populations of *E. amylovora,* there are significant concerns about over or incorrect use of this compound.
- **Biochemical sprays-** Messenger®, a biochemical pesticide containing the harpin protein, has been found to help in control of the blossom blight phase of fire blight, especially when used in combination with streptomycin sprays. This compound has no direct action on the bacterium but activates the <u>S</u>ystemic <u>A</u>cquired <u>R</u>esistance (SAR) genes in the host plant. About 5-7 days are needed to activate the SAR system of the host plant and the effects last approximately 14 days. Therefore, Messenger® needs to be applied several days prior to fire blight infection periods.

- **Biological sprays-** Limited and inconsistent information is available on the efficacy of compounds such as BlightBan®. Check local registration for the availability of this compound.
- **New England Apple Pest Management Guide (current edition)-** This guide is a good reference for detailed information on compounds currently registered for use in Connecticut.

4. Removing Secondary Sources of Inoculum:

- **Cutting of blight strikes-** This is critical for control of secondary spread of fire blight. Over the years the philosophy regarding removal of this shoot blight phase has undergone significant changes-- to prune or not to prune. It is now clear that new infections should be cut as soon as they appear and before significant necrosis is evident. This is especially important for young trees. If the strikes are not cut, the risks of continued spread and rootstock infections are highly increased. When strikes are numerous and distributed throughout a block, first priority should be given to strikes that threaten the main trunk, strikes that appear in the tops of young trees, and strikes on dwarfing rootstocks. Since bacteria in and on freshly cut shoots and limbs can remain viable for some time and serve as a source of inoculum, prunings should be immediately removed and destroyed. However, in blocks with tight spacing, special care must be taken to avoid spreading the bacteria during the process of removal. Where this isn't possible, it is probably best to place prunings in row middles where they can dry. When *thoroughly dry*, they can be mulched with a mower.
- **Methods for making the cuts-** The suggested method of cutting 8-10 inches below visible symptoms has certain limitations since the bacteria can be found as far as 9 feet back on the symptomatic branch. Cuts on symptomatic shoots should be made back to 2-year or older wood at least 8-12 inches below the visible symptoms. Since these cuts often leave a 4-5 inch naked stub above the next leaf, spur, or branch, this method has been called "ugly stub" cutting. Many growers use this method so overwintering cankers can be easily recognized during dormant pruning. Some growers actually spray the ugly stubs with bright colored paint for easy dormant season detection. The idea of disinfesting pruning tools between cuts has also been under scrutiny. Studies have demonstrated that if the ugly stub method is used, the need to disinfest is not necessary if time is a limiting factor. However, it should probably be done as a precaution if time allows. If possible, pruning should be done in dry weather. When pruning is done in wet weather, tools should be disinfested as a precaution. Removal of blight strikes should NOT be combined with routine summer pruning practices.

5. Cultural Practices:

- Use management systems that promote early cessation of tree growth without affecting tree vigor.
- Apply appropriate amounts of fertilizer to maintain vigor. Excessive vigor due to overfertilization increases the risk for fire blight.

- Use of plant growth regulators (e.g., Apogee) to control shoot growth is an area that is still somewhat experimental. Preliminary evidence suggests that applications at late bloom or at petal fall can help slow fire blight infections by reducing shoot elongation on certain varieties.

6. Resistant Varieties:

- Consider the susceptibilities of scion and rootstock to fire blight. Some scion/rootstock combinations are highly susceptible to disease and represent extremely high economic risks. Refer to Tables 1 and 2.

INFORMATIVE WEB SITES

- **Antibiotics and Resistance**
  http:/www.apsnet.org/online/feature/Antibiotics/Top.html

- **General Fire Blight- Michigan**
  http://www.msue.msu.edu/vanburen/fb2000.htm

- **General Fire Blight- West Virginia**
  http://www.caf.wvu.edu/kearneysville/disease_descriptions/omblight.html

- **General Fire Blight- Washington**
  http://www.ncw.wsu.edu/fireblt6.htm

- **Maryblyt®**
  http://www.intrepid.net/afrs/fb8.htm (Maryblyt® home page)
  http://www.caf.wvu.edu/kearneysville/maryblytfaq.html

- **Cougarblight**
  http://www.ncw.wsu.edu/fbsmith.htm

Table 1. Varietal Reactions of Apple to Fire Blight.

Very Susceptible	***Susceptible***	***Moderately Resistant***
Braeburn	Cortland	Delicious
Fuji	Golden Delicious	Early McIntosh
Gingergold	Jerseymac	Empire
Gala	Northern Spy	Liberty
Granny Smith	McIntosh	Priscilla
Idared	Macoun	
Jonagold	Red Free	
Jonathan	Spartan	
Lodi		
Mutsu		
Paulared		
Rhode Island Greening		
Rome Beauty		
Spigold		
Yellow Transparent		

Highly Susceptible Rootstocks: M.26, M.9, Mark

Table 2. Varietal Reactions of Pear to Fire Blight.

Very Susceptible	***Moderately Susceptible***	***Resistant***
Bartlett	Comice	Old Home
Bosc	Winter Nelis	Keiffer
Hardy	BPM	
Starkrimson		
Sensation Red Bartlett		
Max Red Bartlett		

Rootstocks: Bartlett most susceptible on: *Pyrus betulaefolia, P. communis, P. calleryana*

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FACT SHEET

GLOSSARY OF SELECTED PLANT PATHOLOGY TERMS

Dr. Sharon M. Douglas
Department of Plant Pathology and Ecology
The Connecticut Agricultural Experiment Station

Blight- a symptom characterized as dieback of a major portion of a tree; rapid yellowing, browning, collapse, and death of leaves, shoots, and stems, especially young, growing tissues; usually occurs very quickly.

Canker- a symptom characterized as a dead area on twigs, stems, or the main trunk; can be sunken, swollen, or discolored and are usually distinguished from adjacent healthy tissues by color.

Chlorosis- a symptom characterized as yellowing of normally green tissues due to lack of chlorophyll.

Dieback- a symptom characterized as a large portion of dead in a tree; death of the tips of leaves, shoots, and stems; failure of branches to develop, especially in the spring.

Disease- any deviation in the normal functioning of a plant caused by a persistent agent; malfunctioning of plant processes caused by a continuous irritation; a dynamic interaction between a plant and its environment that results in physiological and morphological changes in the plant.

Gall- a symptom characterized as a swelling or abnormal growth of plant tissues; can develop on leaves, stems, and roots; may be induced by insects, fungi, bacteria, or nematodes.

Gummosis- a symptom characterized as exudation of sap or gum from wounds, cracks, or other openings in the bark.

Leaf blotch- a symptom characterized as dead areas of tissue on the foliage, irregular in shape, and larger than leaf spots.

Leaf spot- a symptom characterized as spots of dead tissue on the foliage; the size, shape, and color may vary with the causal agent, but are usually limited to a small portion of the leaf surface.

Necrosis- a symptom characterized as death of plant cells or tissues; necrotic = dead.

Scorch- a symptom characterized as browning and death of indefinite areas along the leaf margins and between the veins.

Sign- the causal agent (pathogen) or its parts or products seen on a plant host e.g., pycnidia, conidia, bacterial ooze.

Stunting- a symptom characterized as reduced plant growth; failure of plant parts to grow to full size; often used to describe an entire plant.

Symptom- the external and internal reactions or alterations of a plant as a result of a disease e.g., wilt, leaf spot, blight, canker.

Vascular discoloration- a symptom characterized as streaking or darkening of vascular tissues.

Wilt- a symptom characterized as loss of turgor or drooping of leaves, shoots, or the entire tree due to apparent lack of water.

Witches' broom- a symptom characterized as abnormal proliferation of shoots from the same point on a plant resulting in a bushy, broom-like appearance.

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Dr. Sharon M. Douglas
The Connecticut Agricultural Experiment Station
Department of Plant Pathology and Ecology
123 Huntington Street, P.O. Box 1106
New Haven, CT, 06504

E-mail: Sharon.Douglas@ct.gov
Phone: (203) 974-8496
(203) 974-8601
Website: www.ct.gov/caes

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The Connecticut Agricultural Experiment Station
Putting Science to Work for Society since 1875

Dr. Sharon M. Douglas
Department of Plant Pathology and Ecology
The Connecticut Agricultural Experiment Station
123 Huntington Street, P. O. Box 1106
New Haven, CT 06504

Phone: (203) 974-8601
Fax: (203) 974-8502
Email: Sharon.Douglas@ct.gov
Website: www.ct.gov/caes

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GYMNOSPORANGIUM RUSTS: COMMON CEDAR RUST DISEASES IN CONNECTICUT

Although there are over 40 species of Gymnosporangium rusts in North America, three species are significant throughout Connecticut and New England. These are Cedar-Apple Rust (*Gymnosporangium juniperi-virginianae)*, Cedar-Hawthorn Rust (*Gymnosporangium globosum*), and Cedar-Quince Rust (*Gymnosporangium clavipes*). These rust fungi are heteroecious, meaning that they require two different hosts to complete their life cycles. The primary hosts are members of the Rosaceae. On these hosts, infections appear as colorful spots on leaves, which is often followed by premature leaf drop. Swellings of midveins, petioles, and twigs, and distortion or dieback of infected twigs can also occur. Fruit can sometimes be distorted. The alternate hosts are evergreens in the genus *Juniperus*. Symptoms on these hosts appear as galls, swellings, witches'-brooms, and twig and branch dieback. These fungi are indigenous and widespread throughout the Northeast, especially in areas where both hosts grow in close proximity.

In 2009, a non-native Gymnosporangium rust, Japanese Apple Rust, *Gymnosporangium yamadae*, was detected on apple and crabapple in Connecticut, as well as Maryland, New Jersey, New York, and Pennsylvania. It is thought that this pathogen has probably gone undetected for many years because it may have been confused with Cedar-Hawthorn Rust, which has very similar symptoms.

CEDAR-APPLE RUST

Cedar-apple rust is caused by the fungus *Gymnosporangium juniperi-virginianae*. The primary hosts are species of *Malus*--apple (*M. domestica*) and crabapple (*M. sylvestris* and other *Malus* species). The alternate hosts are members of the genus *Juniperus*, which includes the native Eastern red cedar (*J. virginiana*) as well as many ornamental junipers (e.g., Chinese, low, and creeping junipers).

The symptoms of cedar-apple rust disease on Eastern red cedar and other junipers are inconspicuous during the winter and appear as brown, kidney-shaped galls that vary in size from ¼-2 inches in diameter (Figure 1). As the temperatures begin to rise in the spring, the fungus begins to grow in the galls (Figure 2). After these conditions, spectacular and distinctive bright orange, gelatinous telial (spore) horns develop and protrude from the surface of these galls (Figure 3). Telia can be up to four inches long. Heavily infected junipers appear to be “decorated” with many colorful galls

Figure 1. Dormant cedar-apple rust gall overwintering on Eastern red cedar.

Figure 2. Gall with telial horns beginning to emerge in early to mid-spring.

Figure 3. Spectacular, gelatinous telial horns develop from galls after rain.

Figure 4. Eastern red cedar “decorated” with many galls in spring.

(Figure 4). Galls can result in dieback of twigs.

Spores called teliospores are produced in the gelatinous spore horns or tendrils. When the teliospores germinate, they produce another type of tiny spore called a basidiospore. These spores can only infect apple and crabapple. Basidiospores are released and carried by wind and driving rain to newly emerging leaves of the alternate hosts, apple and crabapple. As many as 7.5 million basidiospores may be produced in a single gall. These spores have been shown to be carried as far as six miles, but most infections occur within several hundred feet from the source. Once the spores land on the emerging apple or crabapple leaves, they germinate and infect the leaves when they are wet.

Symptoms of infection on the apple and crabapple hosts are also quite colorful. Lesions first appear in early June as greenish-yellow spots that increase in size.

Figure 5. Symptoms of cedar-apple rust on red-pigmented crabapple (upper leaf surface).

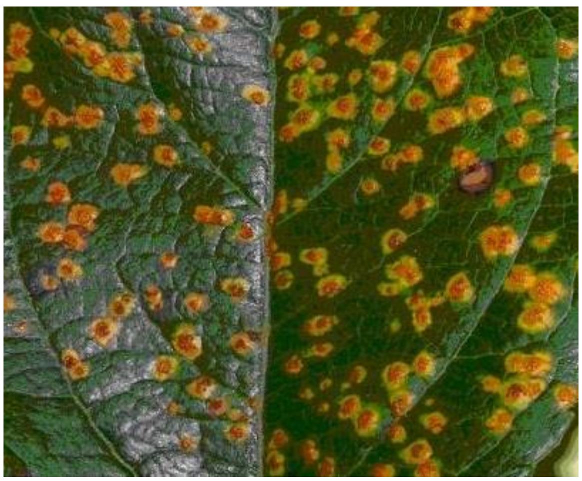

Figure 6. Symptoms on the upper surface of an apple leaf.

Figure 7. Close-up of rust lesion.

They develop into characteristically brightly colored spots--the color can vary from yellowish-orange to red, depending upon the apple or crabapple cultivar (Figures 5, 6, and 7). Symptoms are visible on both the upper and lower leaf surfaces.

Symptoms can develop on fruit and rarely on twigs. By midsummer, minute aecia about $^{1}/_{8}$ inch long (also called “spore cups”) develop at the edge of the lesions on the lower leaf surfaces (Figures 8 and 9).

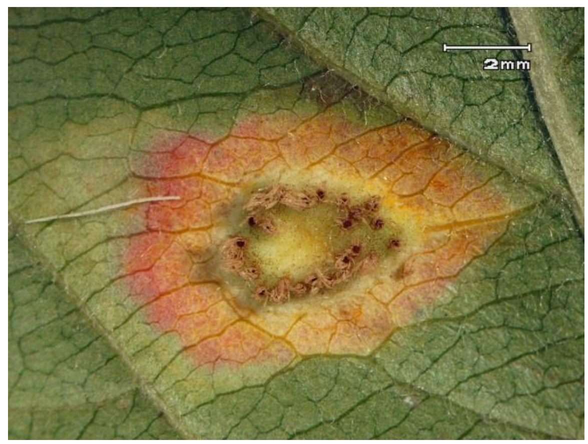

Figure 8. Aecia present in the rust lesion on the lower leaf surface.

Figure 9. Close-up of short, cylindrical aecia.

The spores produced in these cups are called aeciospores. These one-celled spores are released from midsummer into autumn. Aeciospores can only infect junipers and cannot infect other apples or crabapples. These spores are dry and are carried by wind back to the juniper and red cedar hosts. When the spores land, they germinate and stimulate the formation of galls. Galls are initially green to greenish-brown and gradually darken to brown and enlarge as they age. This initiates another cycle of disease. It takes from 19-22 months to complete one life cycle of this fungus.

CEDAR-HAWTHORN RUST

Cedar-hawthorn rust is caused by *Gymnosporangium globosum* and is very similar to cedar-apple rust. However, its primary host range is larger than for cedar-apple rust. The most common hosts are apple, crabapple, and *Crataegus* (hawthorn). Occasional hosts include *Amelanchier* (serviceberry), *Cydonia* (quince), *Pyrus* (pear), and *Sorbus* (mountain ash). The alternate hosts are in the genus *Juniperus*, which includes the native Eastern red cedar (*J. virginiana*) as well as many ornamental junipers (e.g., Chinese, low, creeping, and savin junipers).

Symptoms of cedar-hawthorn rust disease on Eastern red cedar and other junipers are often inconspicuous, especially during winter. They are small brown galls from $^{1}/_{8}$-$^{9}/_{16}$ inch in diameter (Figure 10), and can appear flattened on the side attached to the twig. As the temperatures rise in the spring, the fungus begins to grow in the galls. After periods of moisture, bright orange, gelatinous spore horns protrude from the surface of the galls (Figures 11 and 12). They are typically much smaller and less spectacular than those produced in cedar-apple rust and rarely cause twig dieback.

Teliospores are produced in the spore horns. They germinate and produce tiny basidiospores (Figures 13 and 14).

Figure 10. Dormant cedar-hawthorn gall on juniper.

Figure 11. Small telial horns protruding from a small gall on the stem.

Figure 12. Cedar-hawthorn galls in spring.

Basidiospores are released and carried by wind and driving rain to newly emerging leaves of the alternate hosts, apples, crabapples, hawthorns, and others. Millions of basidiospores are carried distances as far as fourteen miles, but most infections occur within several hundred feet from the source. Cedar-hawthorn rust galls often produce spores for more than one year, unlike the cedar-apple rust galls, which only produce spores for one season.

Once the basidiospores land on emerging apple or crabapple leaves, they germinate and infect the leaves when they are wet.

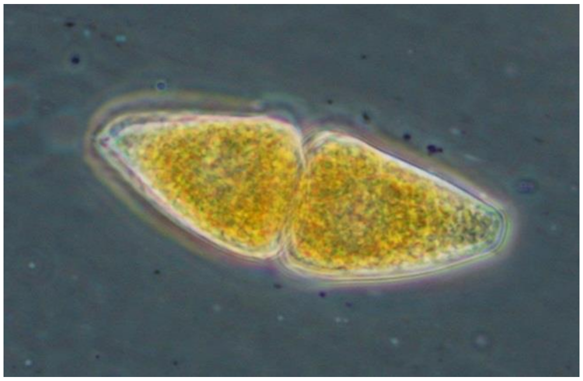

Figure 13. Two–celled teliospore of cedar-hawthorn rust.

Figure 14. Germinating teliospore produces basidia from which tiny basidiospores are formed.

Infections of the rosaceous hosts commonly occur on leaves. However, infections can also occur on fruit, petioles, and twigs. On leaves, rust lesions first appear in early June as greenish-yellow spots that increase in size. They develop into characteristically brightly colored spots--the color can vary from yellowish-orange to red, depending upon the host species and cultivar (Figure 15). Symptoms are visible on both the upper and lower leaf surfaces. By midsummer, aecia are visible on the lower surface of mature leaf lesions as well as on infected fruit, petioles, and twigs. They appear as long tubes, up to ½ inch long (Figure 16), which are distinctly different than the short aecia of cedar-apple rust.

Figure 15. Brightly colored cedar-hawthorn rust lesions.

Figure 16. Aecia protruding from the lower surface of a cedar-hawthorn rust lesion.

Lesions also develop in fruit (Figure 17). Aeciospores are single-celled spores produced in the aecia (Figures 18 and 19).

Figure 17. Young apple fruit with cedar-hawthorn rust lesions.

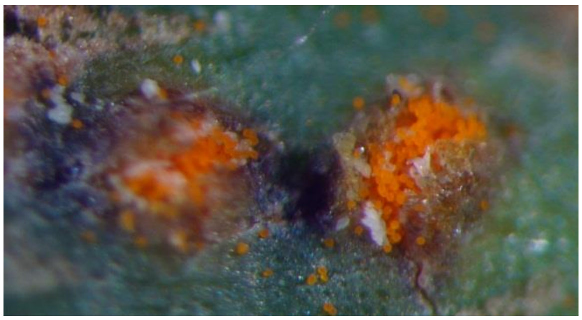

Figure 18. Close-up of aecia with aeciospores breaking through developing fruit.

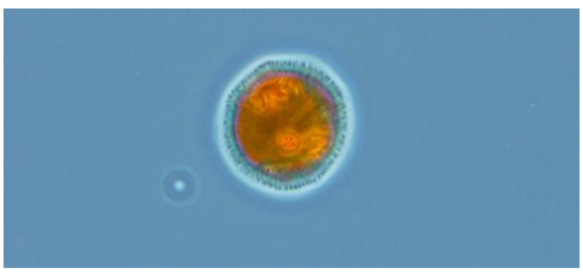

Figure 19. Photomicrograph of an aeciospore of the cedar-hawthorn rust fungus.

These spores are released from midsummer into autumn and infect junipers; they cannot infect other rosaceous hosts. Aeciospores are released anytime during rain or in early morning, in the absence of precipitation. Once on the juniper hosts, they germinate and stimulate the formation of galls, thereby initiating another cycle of disease. Small galls form that are initially green to greenish-brown and gradually darken to brown as they age. It takes approximately 24 months to complete one life cycle of this fungus.

CEDAR-QUINCE RUST

Cedar-quince rust, caused by the fungus *Gymnosporangium clavipes*, is very similar to cedar-hawthorn rust. However, the range of primary, rosaceous hosts is even broader than that of cedar-hawthorn rust and covers over 480 species in 11 different genera. The list includes apple, crabapple, hawthorn, serviceberry, and mountain ash, as well as Aronia (chokeberry), *Chaenomeles* (flowering quince), and *Cotoneaster*. Apples are fairly resistant, although when fruit are infected, they are distorted. The alternate hosts are in the genus *Juniperus*, which includes the native Eastern red cedar (*J. virginiana*) as well as many ornamental junipers (e.g., common, creeping, and savin junipers).

Symptoms of cedar-quince rust disease on Eastern red cedar and other juniper hosts are different than the previously described rusts. Rather than forming galls, infections result in mild swellings of the twigs. Sections of bark in these areas also become flaky. Many twigs die during the first year of infection. The ones that survive become perennial, gradually enlarge, and become spindle-shaped. Telia form each year in these swellings as the temperatures begin to rise in the spring. They first appear as orange, cushion-like masses in cracks in the bark (Figures 20 and 21). After rainfall, the telia gelatinize and become gooey masses that seem to ooze out of cracks in the bark (Figure 22). Telia can be produced in infected twigs for as long as 20 years. Teliospores, formed in the telial masses, germinate and form tiny basidiospores. Basidiospores are released into the air and blown to the rosaceous hosts.

The timing of basidiospore development and release is usually synchronized with bud break of the rosaceous hosts. Eastern red cedars that have been infected with high levels of this rust for many years gradually lose vigor, thin, and decline.

Figure 20. Swellings on juniper with orange telia prior to gelatinization.

Figure 21. Close-up of telia on swollen, spindle-shaped branch.

Figure 22. Gelatinous telial mass oozing out of small branch swelling.

Basidiospores of cedar-quince rust infect leaves, petioles, thorns, young branches, and fruit of rosaceous hosts. On leaves, typical rust lesions (see Figures 6 and 15) can occur, but are not as common as other types of symptoms, which include swelling of midveins or petioles (Figure 23).

Figure 23. Cedar-quince infection of the midvein of a hawthorn leaf results in curling of the leaf.

In addition to leaf infections, this fungus infects and sporulates in developing, green shoots (Figures 24 and 25).

Figure 24. Infection of green *Amelanchier* shoot by the cedar-quince rust fungus.

Figure 25. Close-up of aecia on infected *Amelanchier* shoot.

Shoot and thorn infections can develop, especially on susceptible cultivars of hawthorn. They appear as swollen, spindle-shaped cankers that distort the growth. The fungus can overwinter in the margins of these tissues. In summer, white, tubular aecia form and produce bright orange aeciospores in these structures (Figures 26, 27, and 28).

Figure 26. Shoot and thorn of *Crataegus* infected with cedar-quince rust fungus.

Figure 27. Close-up of white, tubular aecia on infected *Crataegus* thorn.

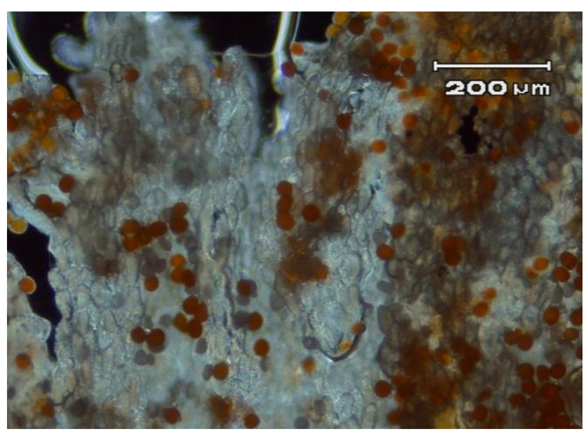

Figure 28. Photomicrograph of bright orange aeciospores present in white aecial tissues.

Fruit of *Amelanchier* and *Crataegus* are commonly infected. However, they are only believed to be susceptible for a short period when they are young. Many white, tubular aecia form on the fruit and the fruit subsequently die (Figures 29 and 30).

Figure 29. Infected *Amelanchier* fruit covered with white, tubular aecia.

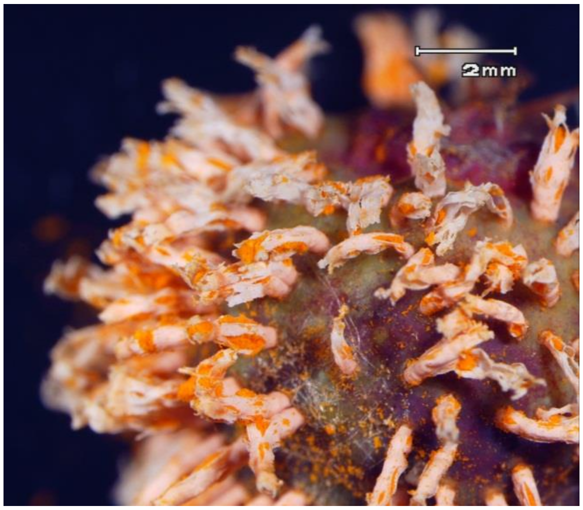

Figure 30. Close-up of aecia containing bright orange aeciospores.

Aeciospores are released from infected rosaceous hosts in response to rain or when aecial drying occurs in response to lower levels of relative humidity. This occurs from midsummer into autumn. Aeciospores infect needles and green tissues of junipers; they cannot infect other rosaceous hosts. Once on the juniper hosts, they germinate and infect the tissues, which remain asymptomatic until the following spring. These infections initiate another cycle of disease. It is still uncertain as to whether the life cycle of cedar-quince rust takes one or two years.

Cedar-quince rust is the most damaging on its rosaceous hosts of the three Gymnosporangium rusts discussed in this fact sheet. This is associated with several factors, including the broad host range and the tissues that it infects—fruit, petioles, and green stems, and the resulting distortion and dieback of stems.

JAPANESE APPLE RUST

Japanese Apple Rust is a non-native Gymnosporangium rust caused by the fungus *Gymnosporangium yamadae*. It was identified in Connecticut in 2009. Rosaceous hosts include *Malus* species such as *M. domestica* (cultivated apple), *M. baccata*, and *M. toringo*. Juniper hosts include *Juniperus chinensis* (Chinese juniper), *J. chinensis var. procumbens* (dwarf Chinese juniper), *J. chinensis var. sargentii* (Sargent juniper), and *J. squamata*. Concern about this new pathogen is focused on how existing cultivars of apple and crabapple that have been bred for resistance to native Gymnosporangium species will react to this non-native species of rust.

A table of the key features of the three common rusts is found at the end of this fact sheet.

DISEASE MANAGEMENT:

Gymnosporangium rust diseases are generally not considered life-threatening to either juniper or rosaceous hosts, though repeated, defoliation can weaken trees and predispose them to winter injury, insects, and opportunistic pathogens. Therefore, these diseases are usually effectively managed through the combined use of culture, sanitation, and resistance. However, with recurrent, significant, defoliation, twig dieback, or fruit loss on rosaceous hosts, fungicide sprays may be necessary.

1. Culture

Involves removal of either host within ½-1 mile from the other, although in most cases this is not a feasible option.

2. Sanitation

Involves pruning and removing galls from the red cedar and juniper hosts during the dormant season. Once again, this is practical in limited situations: where only a few trees are involved and only a few galls are present.

3. Resistance

Involves selection and planting of resistant cultivars or varieties. This can be an effective method for managing these diseases, since this reduces the level of disease that develops. Resistance to cedar-apple and cedar-hawthorn rusts is most common. At present, there is very limited available information about resistance to cedar-quince rust. Some juniper species and cultivars and some rosaceous species and cultivars have been identified to have varying levels of resistance to rust diseases.

Examples of resistant rosaceous hosts:
Apple cultivars: Include 'Delicious,' 'Empire,' 'Jonamac,' 'Liberty,' 'Macfree,' 'Redfree,' and 'Novamac.'

Crabapple cultivars: Include 'Ellwangerina,' 'Henry Kohankie,' 'Ormiston Roy,' 'Snowdrift,' 'Zumi,' 'Red Jewel,' and 'Red Baron.'

Hawthorn species and cultivars: *Crataegus crus-gall, C. intricate, C. laevigata* 'Autumn Glory,' *C. phaenopyrum,* and *C. viridis* 'Winter King.'

Examples of Juniper hosts with resistance: Include *Juniperus virginiana* 'Aurea,' 'Skyrocket,' 'Tripartita;' *J. communis* 'Aureospica,' 'Aurea,' 'Depressa;' *J. horizontalis* 'Argenteus,' 'Douglasii,' 'Plumosa;' *J. sabina* var. *tamariscifolia, J. sabina* 'Broadmoor,' 'Fastigiata;' *J. squamata* 'Meyeri.'

4. Fungicides

The final strategy for disease management involves proper selection, timing, and application of fungicide sprays, especially for high-value, susceptible plants. Thorough coverage of all parts of the tree is necessary and the sprays should be applied until run-off. The fungicide label has information on plant hosts, dosage rates, and safety precautions. Among the fungicides registered for management of Gymnosproangium rusts in Connecticut are azoxystrobin, chlorothalonil, mancozeb, triadimefon, propiconazole, and myclobutanil. Sulfur is an organic management option. Applications will suppress, but not control these diseases. Biological pesticides have not been demonstrated to have significant efficacy.

If harvesting apple or crabapple fruit for consumption, please consult the fact sheet *Disease Control for Home Apple Orchards*. This guide contains information on fungicides registered for use on edible fruit. The fungicide label has information on plant hosts, dosage rates, and safety precautions.

Use of fungicides to protect *Juniperus* species has yielded disappointing results due to the difficulty in determining the timing of the applications—long, midsummer through fall infection periods for these rusts remain poorly understood. One of the only fungicides registered for use for rust control on junipers in the landscape is triadimefon.

October 2010

Key Features of Common Gymnosporangium Rust Diseases

	Cedar-Apple Rust	Cedar-Hawthorn Rust	Cedar-Quince Rust
Deciduous (Rosaceous) Hosts	Apple and crabapple.	Hawthorn, apple, crabapple; sometimes pear, quince, and serviceberry.	Most commonly infected are hawthorn, crabapple, quince, flowering quince, apple, serviceberry, mountain ash, chokeberry, and cotoneaster.
Affected Plant Parts	Mainly leaves; some fruit infections can occur.	Mainly leaves; occasionally petioles, fruit, and stems.	Mainly thorns, new twigs and fruit; occasionally petioles and midveins of leaves.
Symptoms	Colorful yellow to reddish lesions on leaves, depending on cultivar; premature defoliation may occur.	Colorful yellow to reddish lesions on leaves, depending on cultivar; swelling of petioles; premature defoliation may occur.	On apple, fruit are distorted but foliar lesions are rare; on other hosts, stems and thorns develop swellings; twig dieback can occur; fruit and other infected tissues are covered with aecia.
Appearance of Aecia	Short tubes, approx. $^{1}/_{8}$ inch long.	Long tubes, up to ½ inch long.	Long tubes, up to ½ inch long.
Evergreen (Juniper) Hosts	Mainly Eastern red cedar and some ornamental junipers.	Eastern red cedar, Chinese, low, creeping, and savin junipers.	Eastern red cedar, common, creeping, and savin junipers.
Gall Shape and Appearance	Kidney shaped to round, pea to golf-ball in size; depressions are visible where telial horns develop the following spring.	Small, brown galls from $^{1}/_{8}$ - $^{9}/_{16}$ inch in diameter; they can appear flattened on the side attached to the twig.	Subtle, elongated swelling of the twig; some cracking and roughness to the bark.
Number of Years Telia are Produced	One year, usually the spring following gall development.	May produce telia for several growing seasons or years.	One or more years (can be as long as 20 years).
Twig Death	Twig dieback commonly occurs.	Seldom results in twig dieback.	Twig dieback can occur.
Distance Spores Travel Between Hosts to Cause Infection	Usually within several hundred feet, but reported as far as six miles.	Usually within several hundred feet, but reported as far as 14 miles.	Unknown.

Dr. Sharon M. Douglas
Department of Plant Pathology and Ecology
The Connecticut Agricultural Experiment Station
123 Huntington Street, P. O. Box 1106
New Haven, CT 06504

Phone: (203) 974-8601
Fax: (203) 974-8502
Email: Sharon.Douglas@ct.gov
Website: www.ct.gov/caes

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HOW TO IDENTIFY TREE HEALTH PROBLEMS

The process of identifying tree health problems can be simplified by following a logical progression of steps that integrate observations and information regarding the history of the symptomatic tree. These steps are relevant whether you're dealing with abiotic or biotic causal factors or with trees, shrubs, or herbaceous plants. In order to accurately diagnose tree health problems, it often helps to start by asking some key, but basic questions.

SOME BASIC QUESTIONS:
1. Is the growth normal?
2. Is there a pattern to the distribution of abnormal trees or symptoms?
3. What part(s) of the tree is affected?
4. What are the symptoms?
5. What were the past management practices, weather conditions, soil type, site?

THE DIAGNOSTIC PROCESS:

As follows are steps that are helpful in the diagnosis of plant health problems.

Step 1. Identify the Tree

- It is important to identify the tree to the **genus** level. In some cases, identification to **species** and even **cultivar** is necessary in order to be able to determine the normal characteristics and attributes of the tree.
- What should the tree look like at this stage of growth or at this time of year? Does it appear to be normal?
- If not, what is abnormal about the tree?

Step 2. Determine What is Abnormal

- Check for symptoms and signs of possible agents.
- Symptoms of disease are defined as the external and internal reactions or alterations of a tree as a result of a disease (e.g., wilt, leaf spot, blight).

Look for Symptoms (Common Abnormalities)-

- *Leaf spot*- spots of dead tissue on the foliage; the size, shape, and color may vary with causal agent and host; usually limited to small portion of the leaf surface;

- *Leaf blotch*- dead areas of tissue on foliage; irregular in shape and larger than leaf spots;

- *Blight*- dieback of a major portion of a tree; rapid yellowing, browning, collapse, and death of leaves, shoots, stems; especially young, growing tissues; usually occurs very quickly;

- *Scorch*- browning and death of indefinite areas along the leaf margins and between veins;

- *Wilt*- loss of turgor or drooping of leaves, shoots, or the entire tree due to apparent lack of water;

- *Canker*- dead area on a stem or branch; can be sunken, swollen, or discolored and are usually distinguished from adjacent healthy tissues by color; can appear on twigs, stems, and main trunk;

- *Stunting*- reduced plant growth;

- *Gummosis*- exudation of sap or gum from wounds, cracks or other openings in the bark;

- *Gall*- a swelling or abnormal growth of plant tissues; can develop on leaves, stems, and roots; may be induced by insects, fungi, bacteria, or nematodes;

- *Chlorosis*- yellowing of normally green tissues due to lack of chlorophyll;

- *Necrosis*- death of tissue; necrotic=dead

- *Dieback*- large portion of dead in a tree; death of the tips of leaves, shoots, and stems; failure of branches to develop, especially in the spring;

- *Vascular discoloration*- streaking or darkening of vascular tissues;

- *Witches' broom*- abnormal proliferation of shoots from the same point on a plant resulting in a bushy, broom-like appearance;

Is there a pattern to the distribution of abnormal trees or symptoms?

- How many trees are affected? Are they of different species?
- Where are the trees located? A field, glasshouse, landscape, forest, or indoors in a house etc.?
- Is there a pattern to trees that are symptomatic? Is it associated with drainage patterns, soil type, etc.?
- How much of the tree is involved? (whole tree *vs.* part of the tree, new growth or growing tip *vs.* older tissues)

What part(s) of the tree is affected?

- If leaves are symptomatic, which ones (old *vs.* new growth, top *vs.* bottom)?
- If stems are affected, are there cankers, splits, or oozing?
- Look at the condition of the wood by cutting into it; is the cambium healthy and green or is it discolored, brown, and dry? Check the condition of buds to see if they are apparently viable and green.
- If roots are affected, look for discolorations, lesions, stunting, mal-

formations, poor development and growth.

- If the whole tree is affected, look at type of dieback and associated symptoms; was it gradual or sudden death? Sudden death often results from transplant shock, environment, misapplied chemicals, etc.

Look for signs of a causal agent-

- Are there any visible fruiting structures on the affected tissues?
- Is there any oozing along branches or limbs?

<u>Step 3.</u> Obtain Background Information and History

- Weather patterns (drought, unusual winter, prevailing winds, exposure, frosts, etc.)
- Soil and site characteristics (soil pH, macro- and micronutrient levels, soil texture, bulk density, organic matter, soil volume and depth, air and water drainage patterns, frost pocket, etc.)
- Cultural practices (watering, fertilizing, pesticide usage, when was it planted, B&B or container grown, planting practices, etc.)
- Genetic characteristics (hardiness, longevity, etc.)
- Other factors (construction, traffic patterns, any under plantings, where was the plant originally grown, air pollution, history of pesticide use, etc.)

<u>Step 4.</u> Identify the Causal Agent or Collect Samples to Submit to a Specialist for Identification

- Consult references or submit samples for professional diagnosis

<u>Step 5.</u> Devise a Management Program *(Tree Health Program)*

- Program should be based on integrated use of culture, sanitation, resistance, and chemical methods for control.
- Some factors for consideration *if* fungicides are to be part of the management program:
    - Is the host tree valuable? How old is the tree (e.g., is it well established, newly transplanted?)
    - Has the disease been properly identified?
    - Is the disease life- or health-threatening or cosmetic?
    - Does the tree have a history of this disease?
    - Are effective, legal treatments available?
    - Will one or two applications be sufficient for control?
    - Have all other options for management of the disease been explored?

EXAMPLES OF SEVERAL POSSIBLE SCENARIOS:

IF the tree is chlorotic--

Look for pattern (nutritional, herbicide, virus); is the entire leaf affected? (environmental, cultural, chemical, genetic); Are there irregular spots? (virus, insect, chemical)

IF there is necrosis-

How extensive is it? (chemical, cultural, environmental, disease); Look for cankers if entire branch is dead; Is the entire leaf brown? Just portions or the margin? Any pattern to necrosis? Spots? (possibly insect, frost, disease).

IF there is abnormal growth-

Leaves twist and curl (chemical, insect, disease, mechanical, environmental, frost); Symptoms on stem or witches broom (disease, insect); Whole tree stunted from root damage, poor management, environ., disease, insect.

IF there are missing or damaged parts-

- Bark missing- could be deer, rodents, insects, mechanical injury;
- Swelling on trunk- burlap/string still attached to shrub or tree;
- Leaves with holes or notches or skeletonized could be disease, insect, physiological factors;
- Roots- look at color, for any distortion look at structure, growth, size (chemical, insect, disease, culture).

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Dr. Sharon M. Douglas
Department of Plant Pathology and Ecology
The Connecticut Agricultural Experiment Station
123 Huntington Street, P. O. Box 1106
New Haven, CT 06504

Phone: (203) 974-8601
Fax: (203) 974-8502
Email: Sharon.Douglas@ct.gov
Website: www.ct.gov/caes

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JUNIPER TIP BLIGHTS

Tip blight and progressive dieback of twigs is common on juniper and occasionally on arborvitae, white cedar, false cypress, hemlock, true fir, and Douglas-fir. In Connecticut, these are primarily caused by two different fungi, *Phomopsis juniperovora* (Phomopsis tip blight) and *Kabatina juniperi* (Kabatina tip blight). However, tip blights can also be associated with cultural, physical, or environmental factors (abiotic factors) such as poor site selection, winter drying and injury, drought, or other similar stresses. Additionally, tip blights can be confused with damage from juniper tip midge and juniper midge. Fungal tip blights become less problematic as plants age, although they can be found on established, older plants, especially on those growing under crowded or stressful conditions.

Figure 1. Tip blight on juniper—note random distribution of symptoms within the canopy.

SYMPTOMS:

Symptoms can develop at random within the canopy of the plant (Figure 1). Tips of affected branches turn brown or ash gray and often show progressive dieback. In extreme cases, the entire plant can be killed, especially young or newly transplanted plants.

Phomopsis tip blight, caused by the fungus *Phomopsis juniperovora*, generally infects healthy, newly developing, immature needles and shoots in spring. However, the fungus can infect any time during the growing season when young, succulent tissue is present. For example, late-season infections frequently occur when plant growth is prolonged by shearing and over-fertilization. Initial symptoms develop as yellow spots on the young needles. These can appear several days after infection. The fungus then progresses into healthy, young stem tissues, where it girdles the stem and results in dieback of the new shoots (Figure 2). These initially appear chlorotic and eventually turn tan or brown. As the disease progresses, small lesions (cankers) form on the stems where infected and healthy tissue meet (Figure 3). Infections typically move from the tips of branches and appear to gradually move into the stem. Eventually the entire branch may die. Repeated infections can occur during cool, wet periods in spring or fall. Symptoms of Phomopsis tip blight are usually visible by midsummer.

Figure 2. Young, succulent shoots are infected in spring.

Figure 3. As the infection expands, tips develop a blighted appearance. Note the transition from infected to healthy tissue (arrow).

Kabatina tip blight is caused by the fungus *Kabatina juniperi*. The symptoms are very similar to those associated with *Phomopsis*. However, *Kabatina* usually infects wounded, one year or older twigs and does not infect healthy tissues. Infections are associated with injuries from pruning, insect activities, or severe winter weather. Infections usually occur in the fall, so symptoms of Kabatina tip blight generally show up when foliage begins to regain its seasonal color in early spring (March or April)—notably before symptoms of Phomopsis tip blight appear.

DISEASE SPREAD:

Phomopsis and *Kabatina* overwinter in fruiting structures on infected twigs or in plant debris on the ground. In later stages of disease development, small, dark fruiting bodies can be found on blighted needles and twigs. *Phomopsis* fruiting bodies (pycnidia) produce spores throughout the season during wet, cool weather. However, spring and fall infections are most common (Figure 4). In contrast, *Kabatina* fruiting bodies (acervuli) produce spores in fall, when most infections occur (Figure 5). Spores of both fungi are spread by splashing or wind-driven rain.

Figure 4. *Phomopsis* fruiting bodies (pycnidia) (arrows) on symptomatic shoots.

Figure 5. Rows of *Kabatina* fruiting bodies (acervuli) (arrows) visible in symptomatic tip.

To complicate matters further, twig death from abiotic factors can sometimes appear the same as the fungal-associated blights since fruiting structures of saprophytic fungi (ones that colonize dead tissue) look like plant pathogens (fungi that cause disease). Therefore, the first step to an effective management program is to accurately identify the cause, so microscopic examination is necessary to distinguish *Phomopsis* from *Kabatina.*

Phomopsis produces two types of one-celled, colorless spores (conidia) called alpha conidia. These are ellipsoid and have two distinct oil droplets at either end (Figure 6). Beta conidia are the second type of spore and they are filamentous and slightly curved (Figure 7).

Kabatina produces one type of colorless conidia that is similar to the alpha conidia of *Phomopsis* in size and shape, but lack oil droplets. Viable spores of both fungi can be found on branches that have been dead for as long as two years.

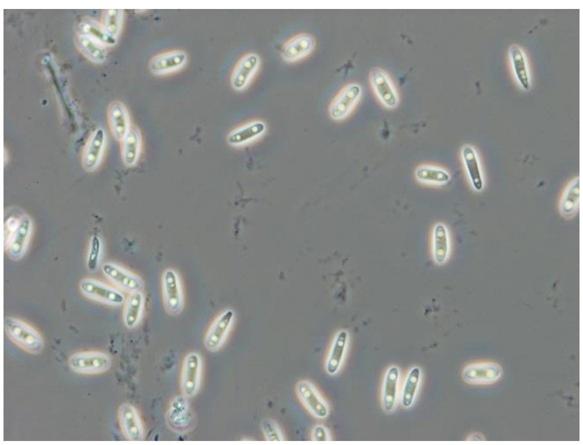

Figure 6. *Phomopsis* spores (alpha conidia) have two distinct oil droplets. *Kabatina* spores are very similar in appearance and size, but lack the oil droplets.

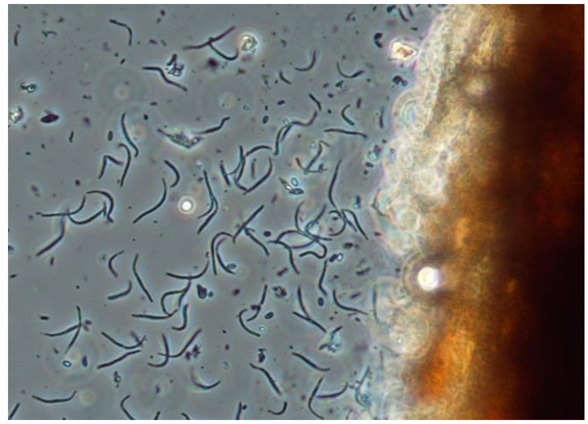

Figure 7. Beta conidia of *Phomopsis*.

MANAGEMENT STRATEGIES:

Tip blights can be managed by following a multifaceted approach. Regardless of the cause, dead tissue should be pruned several inches beyond symptomatic tissue and removed from the planting area. Pruning should be done when the foliage and bark are dry. If possible, tools and equipment should be disinfected with a 10% solution of household bleach, 70% alcohol, or a commercially available compound (e.g., Greenshield, Oxidate).

When watering, avoid overhead irrigation and wetting the foliage or water early in the day to encourage rapid drying. This helps to minimize conditions favorable for infection by both fungi.

New plantings should have adequate spacing to provide good air circulation. Pruning of older plantings can help to reduce tip blight by improving air drainage and foliar drying. It is also important to avoid wounding during transplanting and cultivating.

Plants should be kept as vigorous as possible by following a sound cultural program of fertilizing “as-needed” (determined by soil and/or tissue tests), controlling insect infestations, and watering during any periods of drought.

Resistance can be variable, especially among species and cultivars of juniper. If tip blights are recurring and persistent problems on junipers in a particular site, resistant species or cultivars should be considered for use. Many species of juniper have been reported to be resistant to at least one of the tip blights. For example, *Juniperus chinensis* 'Femina' and 'Pfitzeriana' and *J. comminus* 'Depressa' and 'Saxatalis' are reported to be resistant to *Phomopsis.* *J. chinensis* 'Hetzii' and *J. communis* 'Hibernica' are resistant to *Kabatina.* Additionally, some cultivars are resistant to both fungi and include *J. chinensis* 'Keteleeri,' Mountbatten,' and 'Pfitzeriana'; *J. squamata* 'Prostrata,' and *J. chinensis* var. *sargentii* 'Glauca.'

Fungicide applications can supplement other management strategies for both Phomopsis and Kabatina tip blights. However, the timing of applications will vary depending upon the fungus. Treatment for Phomopsis tip blight should begin when new growth begins to emerge in spring, with follow-up applications at 7-14 day intervals (when conditions are favorable—wet, cool, and cloudy—or according to label instructions) or until new growth is mature and dark green. In contrast, treatments for Kabatina tip blight should begin in late summer or fall since they are targeted to protect tissues from infection. Among the products registered for use for management of *Phomopsis* in Connecticut are thiophanate-methyl, thiophanate-methyl + mancozeb, and copper-based products. Fungicides that specifically list *Kabatina* on the label are limited in Connecticut. However, mancozeb or thiophanate-methyl + mancozeb are registered. Since it is not uncommon for a plant to be infected with <u>both fungi</u>, the combination product of thiophanate-methyl + mancozeb can be used to manage both diseases. All fungicide labels will contain information on dosage rates, intervals for use, and safety precautions.

September 2012 (revised)

Dr. Sharon M. Douglas
Department of Plant Pathology and Ecology
The Connecticut Agricultural Experiment Station
123 Huntington Street, P. O. Box 1106
New Haven, CT 06504

Phone: (203) 974-8601
Fax: (203) 974-8502
Email: Sharon.Douglas@ct.gov
Website: www.ct.gov/caes

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LEAF SPOT DISEASES OF ORNAMENTAL TREES AND SHRUBS

Leaf spot diseases are probably the most common types of plant diseases in the Northeast and Connecticut. These diseases are most widespread after relatively cool, wet spring weather, since free water on leaf surfaces is usually necessary for infection. Most common ornamental trees and shrubs are hosts to one or more leaf-infecting pathogens. In most cases, leaf spots are considered to be more aesthetic than life-threatening problems, although they can result in significant and sometimes disconcerting premature leaf drop.

CAUSAL AGENTS:

Most leaf spot diseases are caused by fungi, although other organisms, such as bacteria and nematodes, can also cause foliar diseases. Some of the fungi associated with leaf spots are *Alternaria*, *Ascochyta*, *Blumeriella*, *Cercospora*, *Colletotrichum*, *Entomosporium*, *Gnomonia*, *Guignardia*, *Mycosphaerella*, *Phyllosticta*, *Septoria*, *Tubakia*, and *Venturia*. Common bacteria associated with leaf spots are *Pseudomonas* and *Xanthomonas*. Foliar nematodes, *Aphelenchoides*, are the most common nematodes on woody ornamentals.

SYMPTOMS:

Leaf spot symptoms vary with the plant host and the causal agent. However, typical leaf spots usually have fairly defined margins and brown, black, tan, or reddish centers (Figures 1-9). Spots vary from pin-head to several centimeters in diameter and can coalesce to encompass entire leaves. Some spots are circular and others are irregular in shape, some are raised, some spots drop out and give the leaf a shot-holed appearance (Figures 7 and 8), and some spots have distinct yellow haloes (Figure 8).

Figure 1. Didymosporina leaf spot of Norway maple.

Heavily infected leaves turn yellow and brown, shrivel, and drop prematurely. Partial to complete premature defoliation of a tree or shrub may occur under some circumstances. For example, crabapples heavily infected with scab are often defoliated by mid-July.

Figure 2. Cercospora leaf spot of mountain laurel.

Figure 3. Entomosporium leaf spot of hawthorn.

Figure 4. Septoria leaf spot of birch.

Figure 5. Scab of crabapple.

Figure 6. Cercospora leaf spot of rhododendron.

Figure 7. Shot-hole of cherry caused by the fungus *Wilsonomyces.*

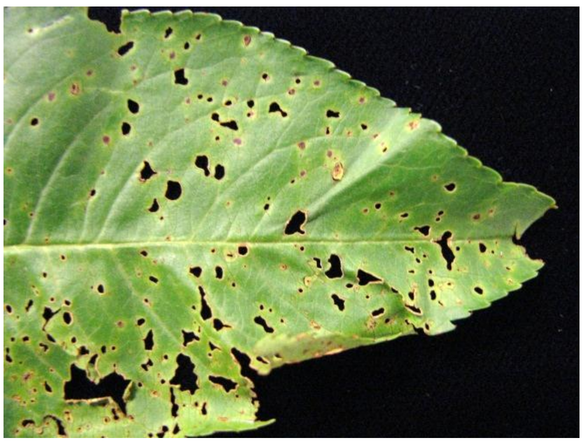

Figure 8. Bacterial (*Xanthomonas*) leaf spot of peach.

Figure 9. Bacterial leaf spot of PJM rhododendron. Note that the spots are irregular in shape.

DISEASE DEVELOPMENT:

Although several different genera of fungi cause leaf spots, their disease cycles are similar. In most cases, the fungi overwinter on fallen leaves and plant debris. In spring, fruiting bodies mature to produce fungal spores (Figures 10 and 11) that are carried by wind or wind-driven or splashing rain to newly emerging leaves.

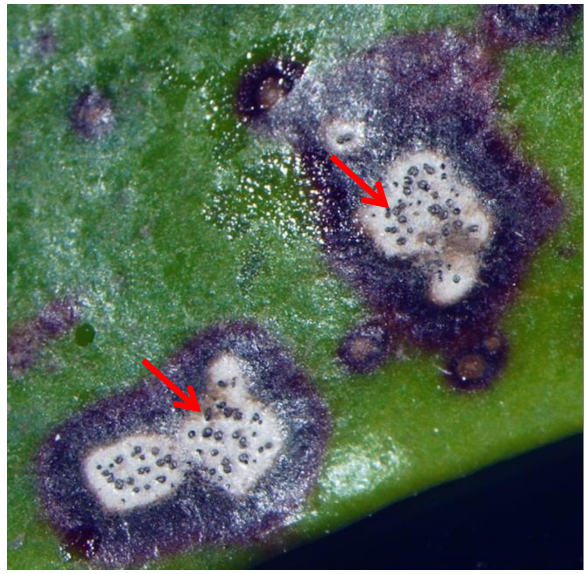

Figure 10. *Cercospora* fruiting bodies (pin-point clusters of black dots—arrows) overwinter in leaf spots of symptomatic mountain laurel leaves.

Figure 11. Oozing tendrils of spores (arrow) of Blumeriella leaf spot of cherry.

Once on the leaf surface, the spores germinate, penetrate, and infect the leaf. Although infections have occurred, there is usually a time lag before visible symptoms develop. Depending on the fungus, there may be one or several cycles (generations) of the pathogen in one growing season. Because of the time lag in symptom expression, by the time leaf spot symptoms are visible, it is usually too late to apply fungicides to manage the disease. Similar cycles occur with bacterial leaf spots, although bacteria are often spread throughout the season.

Most of the fungi that cause leaf spots are fairly host-specific and do not move casually to a wide range of different plant hosts. However, since they all require very similar environmental conditions for infection, they often appear on different hosts at about the same time. To the casual observer, they all look like the same infection "gone wild."

The presence and severity of leaf spot diseases can vary from year to year. This is influenced by the weather and the amount of inoculum. Leaf spots are most likely to develop when there are high levels of overwintering inoculum from heavy infections the previous season and when there are extended periods of cool, wet weather during April, May, and June when leaves are emerging.

MANAGEMENT:

Leaf spots can be managed using a variety of strategies. They are rarely serious enough to warrant yearly chemical control and are often effectively managed by following good sanitary and cultural practices. In fall, it is important to rake and remove fallen leaves from the vicinity of the tree or shrub since many of the leaf-spotting fungi persist on fallen leaves and in plant debris. This practice reduces the overwintering inoculum and the number of spores available to infect emerging leaves in spring.

It is also helpful to follow sound cultural practices that promote plant vigor. These include proper watering, fertilizing (as needed or as suggested by a soil test), mulching, and appropriately timed pruning. Leaf spots are most severe under crowded and shaded conditions.

Leaf spots are especially problematic on new transplants or on weakened or stressed plants. In such cases, chemical control can be helpful, especially in cool, wet springs. However, accurate diagnosis of the specific leaf spot is often necessary to select the most efficacious fungicide for control. Among the fungicides registered for use in Connecticut are thiophanate-methyl, chlorothalonil, and mancozeb. Organic options include sulfur and copper compounds. Several biological products can also be used as protectants, some of which are acceptable for organic standards. These include *Trichoderma harzianum* Rifai strain KRL-AG2, *Streptomyces griseoviridis* strain K61, *Bacillus amyloliquefaciens* strain D747, and *Bacillus subtilis* strain QST 713. The pesticide labels contain information for use, including specific plant hosts and diseases, dosage rates, and safety precautions. Since most leaf-spotting fungi infect in spring as new leaves are emerging, the first fungicide spray is usually applied at bud break. Additional applications may also be necessary in unusually wet and prolonged springs. When symptoms are visible on the new leaves, it is usually too late for effective chemical control.

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Dr. Sharon M. Douglas
Department of Plant Pathology and Ecology
The Connecticut Agricultural Experiment Station
123 Huntington Street, P. O. Box 1106
New Haven, CT 06504

Phone: (203) 974-8601
Fax: (203) 974-8502
Email: Sharon.Douglas@ct.gov
Website: www.ct.gov/caes

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NEEDLECASTS OF DOUGLAS-FIR

Two of the most common diseases of Douglas-fir (*Pseudotsuga menziesii*) growing in Connecticut are Rhabdocline needlecast and Swiss needlecast. Although both diseases are generally considered more aesthetic or cosmetic than life-threatening, they can result in premature defoliation and deformity of heavily infected trees.

RHABDOCLINE NEEDLECAST

Rhabdocline needlecast is the most common disease of Douglas-fir. Outbreaks continue to plague many landscape trees as well as trees in Christmas tree plantations throughout Connecticut. This disease was first reported in the 1920's and has steadily increased in both incidence and severity for the past few years. This increase can be attributed to a number of factors including the weather, increased popularity of planting Douglas-firs as landscape trees, and environmental stress. The primary damage associated with this important disease is defoliation, which leads to suppressed growth, occasional deformity, and value loss in Christmas trees.

SYMPTOMS AND DISEASE DEVELOPMENT:

Rhabdocline needlecast is caused by the fungus *Rhabdocline* spp. Symptoms first become apparent in late fall or early winter as yellow spots or flecks on one or both surfaces of current-season needles. These symptoms can often be confused with feeding damage from the Cooley spruce gall adelgid. The chlorotic spots gradually turn reddish-brown and enlarge. Depending upon the extent of the infection, they can range in size from small, 1- to 2 mm areas, to large brown areas that encompass an entire needle.

A distinctive diagnostic symptom is the sharp border between the healthy green tissue and the infected brown tissue (Figure 1). Discolored needles are most conspicuous in early spring.

Figure 1. Diagnostic brown banding pattern of infected needles. Symptoms become visible in late winter and early spring.

Symptoms are often most severe in the lower portion of the tree where air circulation is poor. Although some of the heavily infected needles drop before or during budbreak, most will persist for several months.

Figure 2. One-year-old needles infected with *Rhabdocline* spp. provide the inoculum to infect the flush of new, susceptible needles (light green).

In late spring, fruiting structures of the fungus develop beneath the epidermis on the lower surface of the needle. The epidermis eventually splits open, usually in two longitudinal lines, and exposes the spores of the fungus (Figures 3 and 4). These spores are carried by rain and wind to newly expanding needles.

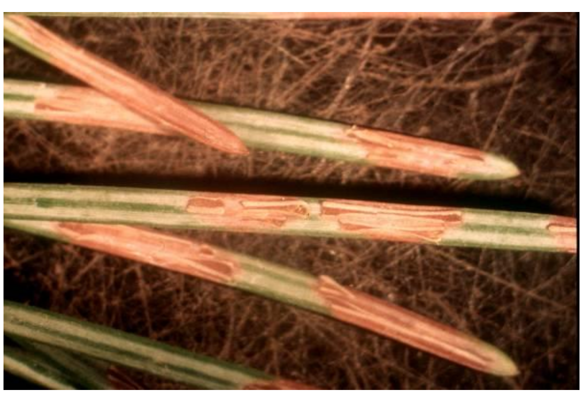

Figure 3. In spring, the epidermis on the lower surfaces of infected needles ruptures in two longitudinal lines.

When the spores land on immature needles they germinate, penetrate the cuticle, and begin to grow within the needle. Although the fungus has already infected the needle, no obvious external symptoms are evident until considerably later, usually by fall or winter.

Figure 4. Close-up of longitudinal splits on the underside of a symptomatic needle. The orange fungal mass will develop into spores that incite new infections.

There is only one infection period per year; infection is favored by cool, moist weather and periods of rain. Rhabdocline needlecast is most damaging in sites where weed growth, close spacing of trees, or dense foliage impede air circulation and prolong wetness on lower branches.

MANAGEMENT STRATEGIES:

Rhabdocline needlecast is not considered a life-threatening disease and can be managed through the combined use of culture, sanitation, resistance, and fungicide sprays. Cultural methods include use of healthy stock and maintaining of tree vigor by following sound cultural practices. It is also helpful to select the appropriate planting site (slopes with good air drainage) and maintain good weed control to promote good air drainage and conditions that help to dry the lower branches.

Sanitation includes pruning and removing any dead or dying branches. There is no need to remove prunings from the vicinity of the tree since the fungus cannot mature on branches once they are cut. It is often necessary to remove severely symptomatic trees to reduce the amount of inoculum. Since spores can be spread from tree to tree by tools, it is helpful to disinfest tools between cuts with household bleach (1 part bleach: 9 parts water), 70% alcohol, or one of the commercially available compounds such as Greenshield®. To reduce spread of disease, pruning should not be done when the foliage is wet.

Resistant seed sources are also available although individual trees *vary greatly* with regard to susceptibility. Among the most resistant are Shuswap and Pillar Lake; Santa Fe, Silver Creek, and Coville are moderately resistant; San Isabel, Lincoln, Apache, Cibola, Kaibob, and Coconino are the most susceptible.

The final strategy for disease management involves the proper selection, timing, and application of fungicide sprays. Thorough coverage of all parts of the tree is necessary. Among the compounds registered for use in Connecticut are chlorothalonil, chlorothalonil + fenarimol, and mancozeb. The labels contain information on dosage rates and safety precautions. Applications are made before or when new growth is approximately ½" long and are repeated for additional sprays at 7- to 14-day intervals depending on rainfall. Sprays should continue until needles are fully elongated and mature, or when conditions are no longer favorable for disease.

SWISS NEEDLECAST

After a number of years of absence, this needlecast has reappeared in both landscape and plantation trees in Connecticut.

SYMPTOMS AND DISEASE DEVELOPMENT:

Swiss needlecast is caused by the fungus *Phaeocryptopus gaumanni*. Symptoms are usually evident in late winter and early spring and appear on one- or two-year-old needles. Affected needles appear yellow or mottled and gradually turn brown. They often have a "dirty" appearance. When the undersides of the needles are examined with a hand lens, two bands of round, black fruiting bodies can be seen on either side of the midrib (Figure 5). With the naked eye, these bands look like "dirt." The fruiting bodies are structures of the fungus that grow out of the stomates (Figure 6).

Figure 5. Black fruiting bodies visible in the white rows of stomates.

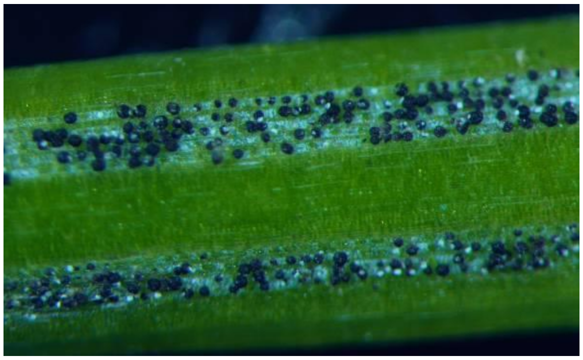

Figure 6. Close-up of fruiting bodies emerging from stomates.

Symptoms typically develop on 1st year needles prior to their 2nd year or on 2nd year needles prior to their 3rd year. However, fruiting structures of the fungus can be present on needles that still appear green and "healthy." As a consequence, infected needles can persist on the tree for two or three seasons before they are dropped or "cast." Because green needles can be infected and serve as a source of inoculum, it is not uncommon for this disease to develop without much notice until a significant number of trees are infected. Repeated infections may weaken trees and severely infected trees usually only maintain current-season needles on their lower branches. In extreme circumstances, disease may result in the death of branches up to 3 feet or more above the ground and may kill trees.

Infection occurs in spring when spores are released from the fruiting bodies. Diseased needles can produce spores for one, two, or three seasons. Spores are disseminated by wind or splashing rain during shoot elongation in late spring and early summer. When spores land on the newly emerging needles, infection occurs. Abundant moisture, high humidity, and cool temperatures are favorable for disease development.

Swiss needlecast is often confused with "sooty mold," which is a superficial, unsightly, non-pathogenic fungus. Sooty molds grow on the honeydew or excrement of insects such as scales, mealybugs, or aphids. Sooty mold can be distinguished from the fruiting structures of the Swiss needlecast fungus by examination with a hand lens. With the latter, individual fruiting structures appear in rows, whereas the sooty mold fungus appears as an amorphous mass of hyphae without any structure or definition.

MANAGEMENT STRATEGIES:

It is helpful to use healthy stock and maintain tree vigor with good weed control, proper fertilization (as determined by a soil test), and attention to planting site. Sanitation includes pruning and removing any dead or dying branches. It is often necessary to remove severely symptomatic trees to reduce the amount of inoculum. Since spores can be spread from tree to tree by tools, it is helpful to disinfest tools between cuts with household bleach (1 part bleach: 9 parts water), 70% alcohol, or one of the commercially available compounds such as Greenshield®. To reduce spread of disease, pruning should not be done when the foliage is wet.

The final strategy for disease control involves the proper selection, timing, and application of fungicide sprays. Thorough coverage of all parts of the tree is necessary. Among the compounds registered for use in Connecticut are chlorothalonil, chlorothalonil + fenarimol, and mancozeb. The labels contain information on dosage rates and safety precautions. Applications are made when new shoots are approximately 1-1½" long and again three weeks later. Additional applications may be necessary in years with excessive rainfall.

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Dr. Sharon M. Douglas
Department of Plant Pathology and Ecology
The Connecticut Agricultural Experiment Station
123 Huntington Street, P. O. Box 1106
New Haven, CT 06504

Phone: (203) 974-8601
Fax: (203) 974-8502
Email: Sharon.Douglas@ct.gov
Website: www.ct.gov/caes

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POWDERY MILDEW

Powdery mildew is considered one of the most common, easily recognized, and widely distributed diseases of herbaceous and woody plants in Connecticut. This disease is primarily of cosmetic concern, since it usually results in disfigured and unsightly plants rather than plant death. However, in some cases, such as powdery mildew of tomato, infections can significantly reduce fruit production and can also result in plant death. Powdery mildew tends to be more problematic in mid to late summer when day-night temperatures favor high relative humidity (RH), although this disease can develop at any time during the growing season.

SYMPTOMS:

Powdery mildews are easily recognized by the white, powdery growth of the fungus on infected portions of the plant host. The powdery appearance results from the superficial growth of the fungus as thread-like strands (hyphae) over the plant surface and the production of chains of spores (conidia). Colonies vary in appearance from fluffy and white to sparse and gray (Figures 1-4). Powdery mildew fungi usually attack young developing shoots, foliage, stems, and flowers, but can also colonize mature tissues. Symptoms often first appear on the upper leaf surface, but can also develop on lower leaf surfaces. Early symptoms vary and can appear as irregular, chlorotic, or purple areas, or as necrotic lesions, all of which are followed by the typical white, powdery appearance. Some infected leaves may shrivel, brown, and drop prematurely. Other symptoms include atypical scab-like lesions, witches'-brooms, twisting and distortion of newly emerging shoots, premature leaf coloration and drop, slowed or stunted growth, and leaf rolling. In rare but extreme situations, heavy infections cause plant death.

Figure 1. Powdery mildew of torenia.

Although diagnosis of powdery mildew is not difficult, symptoms often escape early detection if plants are not periodically monitored, since symptoms can first develop on lower or middle leaves. The time delay from when infections begin and when disease is detected helps explain reports of sudden "explosions" of disease. This can occur when the percentage of infected leaves increases from 10% to 70% in one week.

Figure 2. Powdery mildew of liatris. Note bright white colonies.

Figure 3. Powdery mildew of gerbera daisy.

Figure 4. Powdery mildew of lilac. Note sparse colonies on the leaf.

CAUSAL ORGANISMS AND DISEASE DEVELOPMENT:

Although the symptoms of disease are similar, the fungi responsible for powdery mildew fall into a number of different genera. The most common genera include *Erysiphe, Golovinomyces, Phyllactinia,* and *Podosphaera.* These fungi are all obligate parasites that require living hosts to complete their life cycles so they readily infect healthy, vigorous plants. Some powdery mildew fungi have broad host ranges, whereas others are fairly host-specific. For example, the powdery mildew fungus that infects lilac is not capable of infecting cosmos and *vice versa*. However, the powdery mildew fungus that infects oak can also infect rhododendron and dogwood.

Powdery mildew fungi have fairly simple life cycles on most plants. Spores (conidia) are produced in chains on stalks (conidiophores) (Figure 5). Conidia are "powdery" and are readily disseminated by air currents.

Figure 5. Chains of powdery mildew conidia on conidiophores growing the surface of a leaf (arrows).

After the conidia land on the plant surface, they germinate, penetrate the tissues, and send food-absorbing projections (haustoria) into the epidermal cells. Thread-like strands of the fungus (hyphae) then grow over the surface of the infected plant part and eventually produce more conidiophores and conidia. The time from when conidia land to the production of new conidia can be as short as 72 hours, but is more commonly 5-7 days. Powdery mildew conidia are unique since, unlike most fungal spores, they do not require free moisture (e.g., guttation, dew, rain, overhead irrigation) on plant surfaces in order to penetrate and infect.

Some powdery mildew fungi produce small, black, pepper-like resting structures called chasmothecia (formerly called cleistothecia) (Figures 6 and 7). These structures serve as overwintering structures and also allow the fungus to survive in the absence of a suitable host. Chasmothecia are found in plant debris and in crevices or cracks in woody tissues (i.e., grapevines) and are often the primary sources of inoculum the following spring. Other powdery mildew fungi overwinter as hyphae or fungal strands in buds or other parts of living plants.

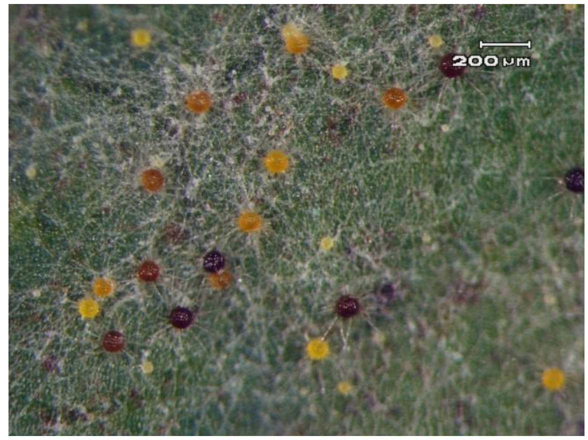

Figure 6. Chasmothecia of different ages of maturity, from immature yellow to mature dark brown or black.

Figure 7. Powdery mildew of grape. Chasmothecia (dark spots) are visible on some fruit.

Development of powdery mildew is influenced by many environmental factors including temperature, RH, light, and air circulation. Because these optimum conditions usually occur in mid to late summer, powdery mildew outbreaks are most common at that time. As a consequence of this timing and the cosmetic nature of the disease, powdery mildews generally don't have long-term health implications for herbaceous or woody plants.

STRATEGIES FOR DISEASE MANAGEMENT:

Managing powdery mildew can be achieved using an integrated approach. This disease can be effectively managed by following good sanitary and cultural practices and is often not serious enough to warrant chemical control.

1. Culture-

- Plant vigor should be maintained by following sound cultural practices such as proper watering, fertilizing, mulching, and pruning.
- Maintain adequate plant spacing to increase air circulation around plants.

2. Sanitation-

- All plant debris should be raked and removed in the fall.
- During the growing season, symptomatic leaves should be removed as soon as they are detected and immediately placed in a plastic bag to avoid spread of the powdery spores to other plants.

3. Scouting-

- Scout for disease on a regular schedule to identify outbreaks before they become widespread.

4. Resistance-

- Genetic resistance is very effective for powdery mildew control, but is not available for all plants. Examples of powdery mildew resistant plants are phlox 'David,' New England aster 'Purple Dome,' beebalm 'Marshall's Delight,' and crabapple 'Indian Summer.'

5. Chemical-

- Since a number of compounds are registered for homeowner use in Connecticut, it is important to read the pesticide label. Spraying usually begins as soon as symptoms are detected and continues until conditions are no longer favorable for disease development. The label will contain information on host plant, dosage rates, application intervals, days-to-harvest interval (for edible crops), and safety precautions. Some of the compounds registered for use include:
  - "Biorational" compounds: neem oil, insecticidal soap, horticultural oil, and potassium bicarbonate.
  - Biological agents: *Bacillus subtilis.*
  - "Traditional" fungicides: copper, fenarimol, myclobutanil, propiconazole, triadimefon, thiophanate-methyl, and sulfur.
  - Organic options include approved formulations of potassium bicarbonate, neem oil, and horticultural oil, copper, and sulfur.

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Dr. Yonghao Li
Department of Plant Pathology and Ecology
The Connecticut Agricultural Experiment Station
123 Huntington Street, P. O. Box 1106
New Haven, CT 06504

Phone: (203) 974-8601
Fax: (203) 974-8502
Email: Yonghao.Li@ct.gov
Website: www.ct.gov/caes

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POWDERY MILDEW OF DOGWOOD

Dogwoods (*Cornus* spp.) are very popular trees in the landscape because of their showy bracts, red berries, and fall color. Powdery mildew is a common fungal disease that damages its natural beauty and also reduces its winter hardiness.

SYMPTOMS AND DIAGNOSTICS

The symptoms of the disease first appear as circular, white patches consisting of fungal mycelia and spores on upper leaf surfaces (Figure 1). As the fungus grows and produces spores, leaves may be covered by white mildew and develop mottled yellow or brownish patches. When new leaves are infected, they curl upward and shoot growth is stunted (Figure 2). Although powdery mildew damage appears to be cosmetic, the disease can result in loss of aesthetics as a result of stunted, distorted growth. Red-brown blotches may develop on leaves during hot, dry summers. Late in the season, light brown to black fungal fruiting bodies called chasmothecia (previously called cleistothecia) form in white mycelial patches on leaf surfaces (Figure 3).

DISEASE DEVELOPMENT

Powdery mildew of dogwood is caused by the fungus *Erysiphe pulchra*. The fungus has two distinctive reproductive stages. In the sexual stage, the fungus produces ascospores in

Figure 1. Early stages of powdery mildew appear as white patches (arrow) on leaves.

Figure 2. Curling and distortion of new leaves (arrows) covered with white mold.

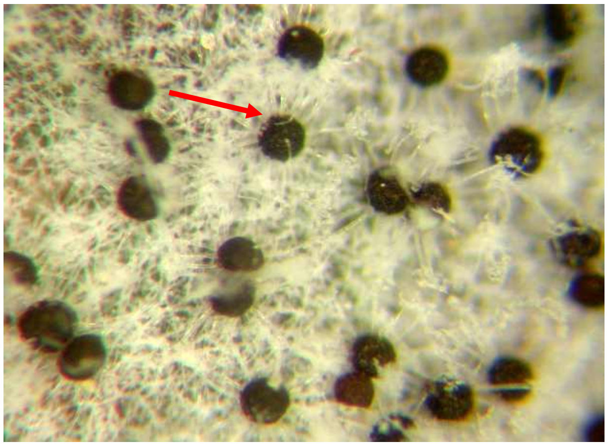

Figure 3. Small, black fungal fruiting bodies (arrow), chasmothecia, in white mold in fall.

chasmothecia that may overwinter. In spring or early summer, these airborne ascospores initiate primary infections on susceptible leaves. Secondary infections may be initiated by conidia, the asexual spores that form in the white fungal patches on infected leaves. Secondary infection cycles cause epidemics of the disease throughout the growing season. Germination of ascospores and conidia generally do not require a film of water on leaf surfaces, but need high relative humidity. Powdery mildew will develop rapidly during extended periods of warm and humid conditions that promote heavy morning dews.

MANAGEMENT

Resistant species and varieties: Several species in the genus of *Cornus* such as *C. kousa*, *C. sericea*, *C. mas*, *C. alternifolia*, *C. alba*, and *C. controversa* are highly resistant to powdery mildew. Flowering dogwood (*C. florida*) is the most popular ornamental dogwood, but powdery mildew resistance is limited in this species. However, some hybrids of *C. kousa* × *C. florida* such as 'Stellar Pink,' 'Stardust,' 'Galaxy,' 'Constellation,' and 'Aurora' are highly resistant to powdery mildew. Recently, resistant flowering dogwood varieties, 'Jean's Appalachian Snow,' 'Key's Appalachia Mist,' 'Karen's Appalachian Blush,' and 'Appalachian Joy' were released from the University of Tennessee.

Proper cultural practices: Collect and dispose of fallen leaves at the end of the season to reduce the primary inoculum for the next season. Prune plants adequately to allow better air circulation. Mulch and water adequately to prevent root stress. Maintain plants in high vigor to withstand disease attack.

Fungicide applications: Fungicide applications may be needed for seedlings in nurseries and for valuable trees in the landscape. Initiate fungicide applications when the first symptoms of powdery mildew are observed. Fungicides that are registered for use on dogwoods in Connecticut include copper products, chlorothalonil, myclobutanil, propiconazole, and thiophanate-methyl. Some biorational products such as Neem oil, insecticidal soap, potassium bicarbonate, potassium salt of fatty acid, and horticultural oil are also effective in reducing disease severity. The fungicide label will contain information on dosage rates, application intervals, and safety precautions.

October 2012

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Dr. Robert E. Marra
Department of Plant Pathology and Ecology
The Connecticut Agricultural Experiment Station
123 Huntington Street, P. O. Box 1106
New Haven, CT 06504

Phone: (203) 974-8508
Fax: (203) 974-8502
Email: Robert.Marra@ct.gov
Website: www.ct.gov/caes

RAMORUM BLIGHT (SUDDEN OAK DEATH) (*PHYTOPHTHORA RAMORUM*)

BACKGROUND

"Ramorum Blight" is the common and inclusive term for a complex of diseases – the best known of which is "Sudden Oak Death" – caused by the oomycete pathogen *Phytophthora ramorum*. "Sudden Oak Death" (SOD) refers to the extensive and rapid mortality, caused by girdling bleeding cankers, of tanoaks (*Lithocarpus densiflorus*) and three species of true oak (coast live oak, *Quercus agrifolia*; California black oak, *Q. kelloggii*; Shreve oak, *Q. parvula* var. *shrevei*), which was initially observed in coastal forests of California and southwestern Oregon. Thousands of acres of California and Oregon forest have been devastated by this disease since it was first observed in Marin County, CA in 1995. It was not until five years later, in 2000, that researchers identified the cause of SOD to be an unknown species of *Phytophthora*. Shortly thereafter, a plant pathologist recognized that the SOD pathogen was identical to an as-yet unnamed *Phytophthora* species first noticed in 1993 causing foliar and tip blights on ornamental rhododendrons and viburnums in Germany and the Netherlands. In 2001 the pathogen was formally named *Phytophthora ramorum*. Since that time, the host list for this federally regulated pathogen has expanded to nearly 140 species of trees, shrubs, and annuals. Hosts span a broad range of genera and plant families, including many that are important in both landscapes and forests of Connecticut and the Northeast (Table 1). The United States Department of Agriculture, Animal and Plant Health Inspection Services, Plant Protection and Quarantine (USDA-APHIS-PPQ) maintains and periodically updates a host list that can be viewed at http://www.aphis.usda.gov/plant_health/plant_pest_info/pram/downloads/pdf_files/usdaprlist.pdf.

The geographic origin of *P. ramorum* is still unknown, but the consensus among scientists is that the introductions into North America and Europe were recent but independent events.

Movement of *P. ramorum* on nursery stock was not observed in CA until 2001. By the spring of 2004, infected plants turned up in nurseries throughout the United States, precipitating an "emergency order" issued by USDA-APHIS-PPQ to restrict the interstate movement of potential host plants from commercial nurseries in California. That same year, the USDA instituted nursery and forest surveys, in which Connecticut has participated annually to date. As a result of these surveys, nursery plants in Connecticut that had been shipped from west coast nurseries have been confirmed to be positive for *P. ramorum* in 2004 and 2006. In 2011, a positive rhododendron from an Oregon mail-order company was traced to a residential landscape in Connecticut, marking the first time for the state, and for the northeast, that this pathogen was detected outside of a nursery (Figure 1). It is important to note that positive finds are always followed by thorough and rigorous eradication procedures as mandated by USDA-APHIS-PPQ.

Figure 1. A mail-ordered *Rhododendron pronum* plant, infected with *Phytophthora ramorum*. This plant was identified as the result of a USDA-APHIS "trace forward" protocol in 2011. Photograph: S. M. Douglas.

Throughout this time, in several southern states *P. ramorum* has been isolated from streams and drainage ditches immediately adjacent to positive nurseries. However, the pathogen has not been found in forests or landscapes beyond these areas; some scientists speculate that extreme summer heat in these regions does not favor spread of *P. ramorum*, a cool weather pathogen.

Also of note, is the rapidity with which *P. ramorum* has spread throughout plantations of Japanese larch (*Larix kaempferi*) in the United Kingdom. Japanese larch was first identified as a host in 2009 when it was found infecting a few dying trees in southwest England. Within three years, *P. ramorum* has devastated nearly 250,000 square miles of larch plantations in all four countries of the UK.

SYMPTOMS

The disease symptoms associated with *P. ramorum* are diverse and primarily determined by the host species. They can range from oozing, killing cankers on trunks and branches to foliar symptoms. Two distinct sets of symptoms have been called Sudden Oak Death and Ramorum Blight (Ramorum Dieback, Ramorum Leaf Blight). The symptoms characteristic of "Sudden Oak Death" result from lethal stem cankers in the bark, cambium, and outer xylem that expand and girdle the stem and kill the tree. These cankers often ooze and bleed. Tanoaks and certain oaks in the red oak subgenus exhibit these symptoms.

Disease symptoms characteristic of "Ramorum Blight" are foliar blighting and shoot dieback. These are the typical symptoms exhibited by many non-oak host species. These symptoms are less severe than cankers and include leaf spots and blotches. In extreme cases, juvenile and mature plants with Ramorum Blight symptoms can be killed. Among the hosts that exhibit these types of symptoms are rhododendron, viburnum, and mountain laurel.

Unfortunately, disease symptoms characteristic of *P. ramorum* infections are often indistinguishable from other diseases or insect injuries that we encounter in Connecticut woodlands and landscapes. If in doubt about what is causing a particular symptom on a plant, The Connecticut Agricultural Experiment Station (CAES) can provide assistance and expert advice.

SPREAD

P. ramorum is unique among other species in the *Phytophthora* genus in that it can infect hosts both through aerial dispersal as well as through soil and water. Extensive studies in California, Oregon, and the U.K. have shown that *P. ramorum* can spread through movement of infected plant material, irrigation water, and soil. The pathogen is only known to reproduce asexually, but it does so with two very different types of asexual spores (Figure 2).

Figure 2. Microscopic view of two types of asexual spores produced by *Phytophthora ramorum*. Photograph: S. M. Douglas.

Sporangia are produced on infected foliage and stems, and are borne aerially, dispersing by means of wind or water. Sporangia can infect directly, or can give rise in water to motile zoospores, which because they are *chemotactic* can recognize and swim to suitable host material (a rhododendron leaf, for example). Chlamydospores form within leaf tissue, and are involved in long-term survival under harsh conditions, such as drought, heat, and cold. None of these spore types has been found on bark cankers.

DETECTION AND DIAGNOSIS

The likeliest means by which this pathogen can be introduced to the eastern United States is by movement of infected plant material. USDA-APHIS-PPQ oversees surveys whose purpose is to limit the potential for accidental spread of this potentially devastating pathogen. Nurseries located in states where *P. ramorum* infections have been documented are inspected prior to shipment, and nurseries in participating states are inspected after shipments from these states are received.

Because symptoms are not diagnostic, presence of the pathogen is determined most efficiently using DNA-based diagnostic assays in the laboratory. These assays are expensive, requiring that both laboratory and personnel be certified by APHIS-PPQ to perform the diagnostics. Currently, only twelve states maintain laboratories and personnel certified for *P. ramorum* diagnostics; the Molecular Plant Diagnostics Laboratory, in the Department of Plant Pathology and Ecology at the Connecticut Agricultural Experiment Station in New Haven, is one of these.

RISK TO CONNECTICUT

Researchers modeling the risk that *P. ramorum* poses to regions of the country not yet affected by the pathogen combine knowledge of the biology of the pathogen with geographic and climatic data. Several such models have been developed; Figure 3 shows the most recently available consensus risk map based on agreement among these models. An important conclusion to be drawn from this map is that Connecticut is at considerable risk for supporting establishment and spread of *P. ramorum* in both landscape and forest. This is due to numerous susceptible hosts, as well as a climate—wet cool periods in both spring and fall—that supports growth of the pathogen.

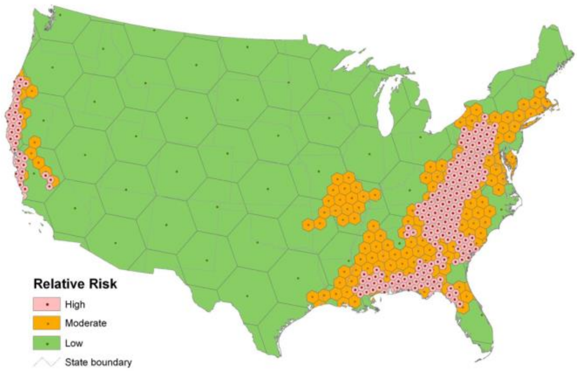

Figure 3. A 2009 risk map generated by the USDA Forest Service, based on host, pathogen, climate, and geographic data.

MANAGEMENT

The best defense against Ramorum blight (SOD) is prevention, since there is no known cure for this disease, once a tree or shrub is infected. And the best way to prevent accidental introduction is to be an informed consumer, knowing the origin of any host material you buy. Research in California has shown that products containing phosphorous acid (phosphite) can be effective in managing the SOD-form of this disease in some cases. These can be applied as bark-drenches or through injection. Either way, they can only be applied by licensed arborists. However, there are no data on the efficacy of this method with susceptible eastern tree species, such as red oak and chestnut oak.

If you are concerned about plants on your property with symptoms suggestive of Ramorum Blight, you can contact the Experiment Station's *Plant Disease Information Office* for assistance: http://www.ct.gov/caes/pdio; 203.974.8601.
December 2012

Table 1. A partial list of plant species known to serve as hosts for *Phytophthora ramorum*. Those not listed as "regulated" by APHIS but have been determined to be susceptible (either

experimentally in controlled-atmosphere greenhouses) or through natural infection in landscapes outside the eastern United States.

Scientific Name	Common Name
Acer pseudoplatanus ‡	Planetree maple
Aesculus hippocastanum ‡	Horsechestnut
Arctostaphylos uva-ursi *‡	Bearberry
Betula alleghaniensis *	Yellow birch
Castanea sativa ‡	Sweet (European) chestnut
Cornus florida *	Dogwood
Fagus sylvatica ‡	European beech
Fraxinus americana *	White ash
Gaultheria procumbens *	Wintergreen
Hamamelis mollis ‡	Chinese witchhazel
Hamamelis virginiana *‡	Witchhazel
Hamamelis x intermedia ‡	Hybrid witchhazel
Kalmia spp. *‡	Mountain laurel, all species
Maianthemum racemosum *‡	False Solomon's seal
Physocarpus opulifolius *‡	Ninebark
Pieris spp. ‡	all species and cultivars
Prunus laurocerasus ‡	Cherry laurel
Prunus serotina *	Black cherry
Quercus alba *	White oak
Quercus prinus *	Chestnut oak
Quercus rubra *‡	Northern red oak
Rhododendron spp. *‡	All species, including azalea
Sassafras albidium *	Sassafras
Syringa vulgaris ‡	Lilac
Viburnum spp. *‡	all species, hybrids, cultivars

* native to northeastern United States

‡ from APHIS list of Regulated Hosts, "proven" or "associated" with *P. ramorum, as of January 2012*

Dr. Sharon M. Douglas
Department of Plant Pathology and Ecology
The Connecticut Agricultural Experiment Station
123 Huntington Street, P. O. Box 1106
New Haven, CT 06504

Phone: (203) 974-8601
Fax: (203) 974-8502
Email: Sharon.Douglas@ct.gov
Website: www.ct.gov/caes

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RHIZOSPHAERA NEEDLECAST

Rhizosphaera needlecast is a common disease that causes premature discoloration, death, and shedding of needles on several conifers in Connecticut landscapes and in Christmas tree plantations. Several species of spruce (*Picea*) are the most common hosts, with Colorado and Engelmann spruce sustaining the most damage in the landscape. Rhizosphaera needlecast is an occasional problem on pine (e.g., Austrian, mugo, and Eastern white), Douglas-fir, and true fir (e.g., noble, silver). This disease is primarily a problem on tree species growing outside of their natural ranges and is rarely found in natural forests.

SYMPTOMS AND DISEASE DEVELOPMENT

Rhizosphaera needlecast is caused by the fungus *Rhizosphaera kalkhoffii.* Current-year needles become infected in May and June, but symptoms do not appear until late summer, fall, or the following spring. In late summer, infected current-year needles appear mottled or speckled, often with dull yellow or reddish blotches. Diagnostic symptoms may develop in early September but typically occur in late winter or early spring, when infected needles turn a distinctive lavender or purplish-brown (Figure 1). At that time, pinpoint black fruiting bodies of the fungus called pycnidia emerge out of the stomates of infected needles. These appear as rows of fuzzy black spots (Figure 2) and are easily distinguished from rows of white stomates on healthy needles (Figure 3) using a hand lens. As the fruiting bodies emerge from the stomates, white waxy caps are sometimes visible on these structures (Figure 4). During periods of rain and wet weather, conidia (spores) of the fungus ooze out of the pycnidia (Figure 5). Spores are easily dispersed by wind-driven rain and splashed onto newly developing needles where infection occurs.

Figure 1. Characteristic purplish-brown color of infected spruce needles.

The infection period for this disease can be quite long since release of spores begins in spring and can continue until autumn. The fungus usually attacks needles on the lower branches first, since needles on these branches tend to stay wet for longer periods. Infections then gradually progress up the tree as spores are splashed to needles on nearby branches or twigs. On severely diseased trees, the infected needles usually fall during their second summer, leaving only the current season's growth on the bottom half. Branches die when they are defoliated for 3-4 consecutive years.

Trees of any size are susceptible to infection. The fungus over winters in infected needles on the tree and in fallen needles. Under epidemic conditions, the fungus may kill lower branches. In extreme cases, Rhizosphaera needlecast can result in tree death.

Figure 2. Pinpoint black fruiting bodies emerging from stomates of spruce needles.

Figure 3. Healthy spruce needle with rows of white stomates.

Rhizosphaera needlecast is often first evident in sites that are naturally moist, have poor air drainage, or are adjacent to taller trees that reduce wind drying of the foliage. *Rhizosphaera* typically infects newly emerging needles of the current season but can attack needles of any age that are dying or stressed by other plant pests or environmental factors. It is well documented that Rhizosphaera needlecast is more severe in drought-stressed trees.

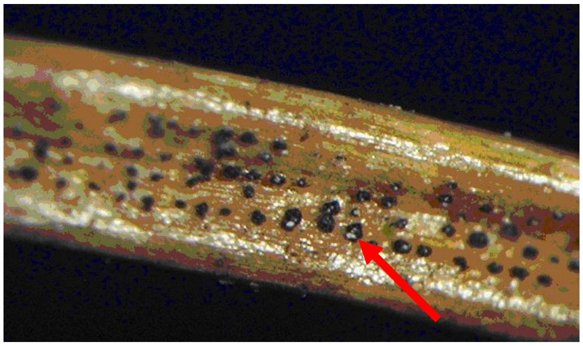

Figure 4. Infected spruce needle with black fruiting bodies of the fungus (pycnidia) emerging through the stomates. Note white waxy caps on some pycnidia (arrow)

Figure 5. Closeup of spores (conidia) oozing out of the fruiting bodies.

MANAGEMENT STRATEGIES

Rhizosphaera needlecast can be managed through the combined use of culture, sanitation, resistance, and fungicide sprays. Although this disease can reduce the marketability or aesthetic value of trees, it is usually not considered life threatening. Cultural methods for management include using healthy stock and maintaining tree vigor by following sound cultural practices. It is also helpful to select appropriate planting sites (slopes with good air drainage) and maintain weed control in order to promote good air drainage and conditions that help to dry the lower branches.

Sanitation includes pruning and removing any dead or dying branches. All prunings should be removed from the vicinity of the tree, since the fungus can mature and continue to sporulate (produce conidia) on branches that are cut. It is often necessary to sacrifice and remove heavily symptomatic trees to reduce the level of inoculum, especially if other susceptible hosts are nearby. This is especially important in a Christmas tree plantation. Human activities and tools can also spread fungal spores from tree to tree. Therefore, it is helpful to disinfest tools between trees (or cuts) with household bleach (1 part bleach: 9 parts water), 70% alcohol, or one of the commercially available compounds such as Greenshield ®. It is also useful to avoid pruning or shearing when the foliage is wet in order to limit spread of the disease.

When possible, it is beneficial to use resistant varieties. Colorado and Englemann spruce are most sensitive, white and Sitka, spruce are intermediate, and black, Norway, and Serbian spruce are relatively resistant.

The final strategy for disease management involves the proper selection, timing, and application of fungicide sprays. Thorough coverage of all parts of the tree is necessary. Among the compounds registered for use in Connecticut are chlorothalonil, chlorothalonil + fenarimol, copper hydroxide, and mancozeb. The labels contain information on dosage rates and safety precautions. Applications are made before or when new growth is approximately 1½" long and again 3 weeks later. Additional applications may be necessary in years with excessive rainfall. The pesticide labels will contain information on dosage rates, application intervals, and safety precautions.

March 2009 (revised)

CAES

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FACT SHEET

RHODODENDRON TISSUE PROLIFERATION

Dr. Lindsay Triplett
Department of Plant Pathology and Ecology
The Connecticut Agricultural Experiment Station

WHAT IS TISSUE PROLIFERATION?

Rhododendron Tissue Proliferation (TP) is a condition that causes tumor-like growths and shoots to form at the base of many cultivars of *Rhododendron*. The majority of susceptible cultivars are elepidotes, but some lepidote and Azalea cultivars can be affected. It can also affect *Kalmia latifolia*, mountain laurel.

IDENTIFICATION:

TP can first be noticed in young plants as an area of hard swollen tissue growing near or below the soil line (Figure 1). Early symptoms can look similar to crown gall caused by the bacterium *Agrobacterium tumefaciens* (Figure 2); however, true crown gall of *Rhododendron* typically occurs at stem junctions on the aerial branches, rather than at the crown.

Later, the tissue swelling will start to differentiate into small shoots appearing at the base of the plant (Figure 3). These may be found entirely below the soil line and require some digging to identify. These are a telltale sign of TP, as gall-forming pathogens of *Rhododendron* are not known to form organized sprouts at the base of the plant.

In older plants, TP may appear as small to normal-sized shoots originating from the base of the plant.

Figure 1. Early symptoms of Tissue Proliferation may include tumor-like swollen tissue near the soil line. Plants were photographed one year after planting.

Figure 2. If no shoots are visible, Tissue Proliferation can appear as a gall at the crown of potted plants. However, this is not true crown gall disease and is not caused by bacteria.

Figure 3. Nodules later develop into a mass of tiny floret-like shoots. Those above the soil line turn green and leaf out. This plant was photographed about two years after planting.

EFFECTS:

Rhododendron plants may survive and even maintain a healthy appearance for years with TP. A 1994 study at CAES found no differences in plant growth or susceptibility to disease or insects between TP and non-TP plants. However, economic losses can occur when visible symptoms cause the plants to be rejected by retailers and consumers. In cases where the callus growth is extensive, there may be a reduced root system and overall reduced vigor of the plant. Severe cases could potentially girdle the roots and cause visible growth defects.

CAUSES:

The causes of tissue proliferation are unknown. No pathogenic bacteria, fungi, or viruses have been found associated with the disorder, despite many attempts to identify some. Attempts to "infect" healthy plants with extracts from TP plants did not cause TP to spread to the healthy plants.

TP is strongly associated with plants propagated from tissue culture, and with cuttings originating from tissue culture propagated plants. TP has rarely been reported on plants originating from cuttings from non-tissue cultured plants or from seed.

One study found that tissue from TP plants can form shoots without addition of the plant hormone cytokinin, while non-TP plants require cytokinin to form shoots. Some scientists have proposed that propagation conditions and hormones may cause the TP plants to abnormally produce or detect cytokinin. However, anecdotal reports have suggested that plants propagated in the same lot at the same facility can have very different rates and severities of TP after delivery to different nurseries. Potted plants are affected more severely than field-grown plants. In short, although the cause remains to be determined, TP could be caused by a combination of cultural, genetic, and environmental factors.

MANAGEMENT STRATEGIES:

Given that the causes are still unknown, post-propagation options for control of TP are limited. However, studies have indicated that conditions that induce rapid growth increase the incidence of TP. Limiting fertilizer rates and avoiding growth enhancers is suggested to reduce the risk of TP.

Because it is non-infectious, TP is not spread through pruning equipment or during bud pinching. However, plants showing any signs of TP should be avoided when selecting sources of new cuttings.

June 2015

Dr. Lindsay Triplett
The Connecticut Agricultural Experiment Station
Department of Plant Pathology and Ecology
123 Huntington Street, P.O. Box 1106
New Haven, CT, 06504

E-mail: Lindsay.Triplett@ct.gov
Phone: (203) 974-8611
Website: www.ct.gov/caes

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FACT SHEET

SEIRIDIUM CANKER OF LEYLAND CYPRESS

Dr. Yonghao Li
Department of Plant Pathology and Ecology
The Connecticut Agricultural Experiment Station

Leyland cypress (× *Cupressocyparis leylandii*) is a fast-growing conifer that has been widely grown to form hedges, windbreaks, and barriers in commercial and residential landscapes. Unfortunately, Leyland cypress is very susceptible to a fungal disease called Seiridium canker-- the increased popularity of planting this conifer in the landscape has led to substantial increases in the incidence of this disease. Seiridium canker can cause branch dieback, damage to the main trunk, and may eventually kill the tree. Physical injuries, such as drought stress and winter damage, can result in Leyland cypress trees becoming more vulnerable to the disease.

SYMPTOMS AND DIAGNOSTICS

The pathogen can infect stems, limbs, and even the trunk. The first evidence of Seiridium canker is a browning or a reddening of the surface of stems. This is followed by the development of sunken, dark-brown cankers that may girdle the small branches and cause dieback (Figure 1). Seiridium cankers are often thinly elongated and show dark-brown to purplish discolorations of stem tissues. Exuding resin may also be observed on the surface of infected areas (Figure 2). Small, black fungal fruiting bodies may be visible on symptomatic tissues (Figure 3). If the pathogen grows into the main trunk and forms cankers, the entire tree can be killed.

DISEASE DEVELOPMENT

Three *Seiridium* species, *S. cardinal*, *S. cupressi*, and *S. unicorne*, are associated

Figure 1. Browning of needles above the dark-brown canker lesion on the stem.

Figure 2. Resin oozing from the infected area and discoloration of cambium tissues.

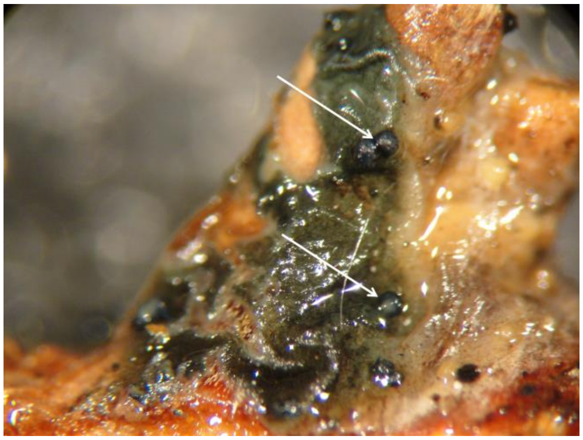

Figure 3. Spores (conidia) released from black fungal fruiting bodies (pycnidia).

with Seiridium canker diseases. They have wide host ranges that include many species in the genera *Chamaecyparis*, *Cryptomeria*, *Cupressus*, *Juniperus*, *Libocedrus*, *Platycladus*, *Taxodium*, *and Thuja*. The pathogens can survive in infected branches and trunks for many years. When environmental conditions are moist and wet during the growing season, spores (conidia) are released from fungal fruiting bodies (pycnidia). These spores are locally dispersed by splashing water from rain and overhead irrigation. The pathogen also can be spread by contaminated pruning tools, movement of infected plant materials, and insects. The pathogens infect stem tissues through wounds that are caused by winter damage, insects, or other mechanical injuries. The optimal temperature for disease development is 77°F. During the hottest months of the year, growth of *S. cardinal* in host tissues is slow or even arrested. Plants that are stressed by drought and freeze damage are particularly vulnerable to the disease. Severe damage is most likely on sites with dry weather and high daytime temperatures, although wet conditions are required for spore dispersal and infection.

MANAGEMENT

Alternative tree species: In areas where Seiridium canker has been a problem, resistant tree species such as *Thuja* 'Green Giant' and *T. occidentalis* 'Smaragd' should be selected for replacement of screens and hedges. Design landscapes using different tree species and cultivars to maintain genetic diversity and to prevent disease outbreaks.

Cultural practices: Plant Leyland cypress in well-drained soil. Maintain tree vigor by watering trees during periods of heat and drought. Avoid overhead irrigation to reduce the risk of disease spread. Space plants adequately to improve air circulation and to prevent rubbing between branches. Scout for the disease and correctly identify the pathogen, which is important for effective disease management. When the disease is found, prune infected branches about 3 to 4 inches below the cankered area. Disinfect pruning tools with either 10% household bleach or 70% alcohol. Severely affected trees should be removed from the area.

Fungicide application: Currently, fungicides are not effective for controlling this disease.

February 2015

Dr. Yonghao Li
The Connecticut Agricultural Experiment Station
Department of Plant Pathology and Ecology
123 Huntington Street, P.O. Box 1106
New Haven, CT 06504

E-mail: Yonghao.Li@ct.gov
Phone: (203) 974-8601
Website: www.ct.gov/caes

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FACT SHEET

SELECT CONIFER DISEASES IN CONNECTICUT

Dr. Sharon M. Douglas
Department of Plant Pathology and Ecology
The Connecticut Agricultural Experiment Station

Every year, the diseases that develop on conifers in the landscape and in Christmas tree plantations are influenced by a number of factors, including the weather, the amount of overwintering inoculum, and the tree species. However, there are several diseases that are common to many different scenarios almost every year.

AUTOECIOUS (REPEATING) SPRUCE NEEDLE RUST

Causal Agent: *Chrysomyxa weirii* (fungus)
Key Hosts: blue and white spruce
Symptoms and Spread:

Symptoms of repeating spruce needle rust are often detected throughout Connecticut, especially on Colorado spruce. These appeared as yellow spots or flecks on one-year-old (occasionally two-year-old) needles. This needle rust is autoecious and only infects spruce, particularly on susceptible blue and white spruce. Since this disease is autoecious, no additional hosts are required to complete the life cycle of the fungus. One of the key features used to distinguish repeating needle rust from other needle rusts is the timing of symptom development. Symptoms appear in early spring, whereas those of other heteroecious Chrysomyxa rusts appear in mid to late summer.

Symptoms first appear as yellow spots or flecks on one-year-old (occasionally two-year-old) needles in late winter and early spring. These spots eventually develop into pustules or blisters (telia) that burst open to reveal masses of yellow-orange spores (teliospores). The teliospores then produce another type of spore (basidiospores) that are readily blown by wind and splashed by rain onto newly emerging needles of the same tree or of adjacent trees.

Yellow spots or flecks develop on needles in late winter and early spring.

Diagnostic rust symptoms develop on one-year needles in spring, before new growth has emerged.

Rust spores blown by wind and splashed by rain onto newly emerging needles.

Close-up of rust pustules.

The new infections occur when needles are tender and immature in spring. Infections often go undetected for the remainder of the season, since outward symptoms are rarely visible. However, the following spring, diagnostic yellow spots and blisters develop on the infected needles and the disease cycle starts again. Blisters of *C. weirii* can be extensive and appear on both one- and two-year-old needles, giving heavily infected trees an overall yellow-orange appearance from a distance. As with most needle diseases that are not fatal, but result in needle drop, repeated defoliation may retard growth and reduce marketability.

Management:

- Use healthy stock and maintain tree vigor. Fertilize at the proper time and rate as determined by a soil test--avoid excessive nitrogen and late- summer and early-fall fertilization.
- Rogue and remove heavily infected trees to reduce inoculum.
- Fungicide sprays:
  - in all cases, **coverage and timing** are **very** important; although rust is not specifically listed on the label, chlorothalonil (e.g., Daconil 2787, Daconil Weather Stik, Bravo) is labeled for spruce and is effective for control;
  - the label contains information on dosage rates and safety precautions;
  - the first application should be made when 10% of the trees have broken some buds; applications should then be made at weekly intervals until needles are mature or until symptomatic needles have dropped to the ground; this is usually 3 sprays but in years where bud break is slow and the weather is cool and there is enough free moisture on the

needles for infection, up to 5 sprays may be necessary.

SIROCOCCUS BLIGHT

Causal Agent: *Sirococcus conigenus* (fungus)

Key Host: many conifers including Douglas-fir and blue and white spruce

Symptoms and Spread:

Symptoms of Sirococcus blight may be observed on Douglas-fir and blue spruce in plantation and landscape trees. Outbreaks are often associated with wet spring weather. Young trees are usually more susceptible, although trees of any age can be infected. Sirococcus blight rarely kills trees, but can disfigure and reduce marketability. However, repeated infections of young trees can result in tree death.

Symptoms first appear on succulent shoots, and occasionally on one-year-old twigs, in midsummer. Affected shoots usually appear at random within the canopy of a tree. This disease can be confused with Botrytis blight, but Sirococcus usually shows up later in the season. Symptoms can also be more pronounced in the lower portions of older trees. This is because low light levels increase the susceptibility of tissues to Sirococcus infection. Blue spruce is highly susceptible and one-year-old shoots are commonly killed.

The fungus attacks at needle bases, girdles the shoot, and results in tip dieback. Infected shoots turn brown and often develop a diagnostic shepherd's crook appearance. Pinpoint, brown fruiting structures of the fungus called pycnidia develop at the bases of infected needles or on infected shoots in mid to late summer or early-fall. These are often visible with a hand lens. The fungus overwinters in these killed shoots and in cone scales.

Spores of the fungus called conidia are spread by splashing rain during spring and into summer. Infections occur when conidia land on succulent tissues of newly emerging shoots, usually during periods of wet weather and when tissues are wet for 24 hours or longer at 10-25°C (50-75°F). The longer the tissues are wet, the more severe the infection. These conditions are common springtime conditions Connecticut. Infections result in stunting or disfigurement of the growing tips.

Multiple shoot tips exhibiting diagnostic shepherd's crook appearance of Sirococcus blight.

Close-up of diagnostic shepherd's crook on infected tips.

Black spots are fruiting structures of the fungus develop on needles in the shepherd's crook.

Management:

- Use healthy stock and maintain tree vigor with good weed control, proper fertilization, and attention to planting site.
- Rogue symptomatic trees.
- Prune and remove any dead or dying branches when the bark and needles are dry.
- Practice good sanitation.
  - spores can be spread from tree to tree by tools so shear healthy trees first or disinfest tools between cuts with household bleach (1 part bleach: 9 parts water) or 70% alcohol;
  - avoid shearing when the foliage is wet to reduce spread of disease;
- Use less susceptible varieties, when possible.
  - blue spruce is highly susceptible;
- Fungicide sprays.
  - in *all* cases, coverage is **very** important!
  - chlorothalonil (e.g., Bravo, Daconil 2787, Daconil Weather Stik), chlorothalonil + fenarimol (TwoSome), and thiophanate methyl + chlorothalonil (e.g., Spectro 90 WDG), and azoxystrobin (e.g., Heritage) are registered for use;
  - the label contains information on dosage rates and safety precautions;
  - begin applications before new growth is approximately ½" long and repeat at label intervals depending on rainfall. Sprays should continue until shoots are fully elongated and conditions are no longer favorable for disease.

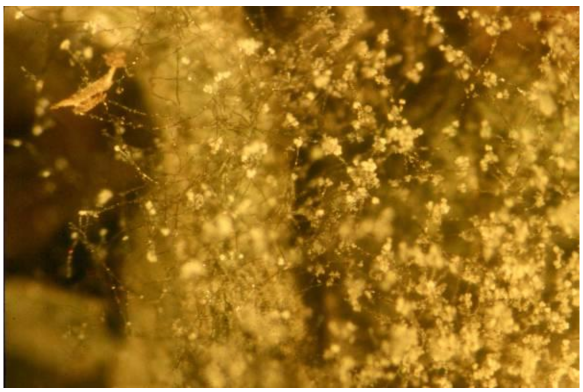
BOTRYTIS BLIGHT

Causal Agent: *Botrytis cinerea* (fungus)
Key Hosts: all conifers, especially spruce and fir
Symptoms and Spread:
Botrytis blight may appear on many species of conifers in both plantations and landscapes. *Botrytis* is often observed on tender, succulent tips that emerge during the extended cool, relatively moist weather.

Botrytis blight can infect most conifers, but is particularly problematic on seedlings, young trees, and trees that have been weakened, but not necessarily killed, by frost or freeze injury. It is also prevalent during periods of extended cool weather when shoots are elongating and immature tissues are present for longer periods than usual. Affected tissues initially appear water-soaked and then turn brown. Brown lesions girdle the shoots and cause them to wither and die.

As the disease progresses, infections are identified by the gray, fuzzy, cottony growth of the fungus on the surface of needles and shoots. The fungus usually moves from the needles to the shoots and into the stems. With the exception of weak trees, infections usually do not extend beyond the current-season's growth and are often confined to tissues that have been damaged by frost.

Spruce tips infected with Botrytis blight. Note: easily confused with Sirococcus infections.



Diagnostic fuzzy brown growth of Botrytis on infected tips.

Botrytis blight is easily confused with Sirococcus blight, since both diseases cause similar symptoms at the tips of shoots. However, one quick way to distinguish them is to put infected tips into a plastic bag with a moist paper towel. Leave this overnight in a warm location, but out of direct sun. If the symptoms are associated with Botrytis, the symptomatic tissues will be covered with fuzzy brown growth within 24-48 hours.

Botrytis blight is a more serious problem on seedlings or young trees than on established trees. On established trees, infected shoots are walled-off and usually drop. On seedlings, young, or weak trees, the fungus can spread into shoots or the main stem, where it causes cankers that eventually girdle and kill the shoot or tree. Refer to the fact sheet *Diseases of Christmas Tree Seedling and Transplant Beds* for more details. The fungus is an aggressive saprophyte, so infections often begin on shaded, senescent needles, and in other plant debris at the base of a tree.

Management:

- Follow sound cultural practices to keep trees as healthy as possible. Weak and frost-damaged tissues are particularly susceptible to infection so it is important to select appropriate planting sites. Fertilize at the proper time and rate as determined by a soil test--avoid excessive nitrogen and late- summer and early-fall fertilization.
- Avoid overcrowding to allow for good air circulation.
- Avoid overhead irrigation or water early in the day so the foliage has a chance to dry.
- Practice good sanitation.
  - spores can be spread from tree to tree by tools so shear healthy trees first or disinfest tools between cuts with household bleach (1 part bleach: 9 parts water) or 70% alcohol;
  - avoid shearing when the foliage is wet to reduce spread of disease;
  - diseased tissues should be removed as soon as they are evident in seedling beds;
- Fungicide sprays are usually not necessary for established trees. However, they can help to minimize damage to seedlings and new transplants.
  - among the compounds registered for use in Connecticut are: mancozeb (e.g., Protect), chlorothalonil (e.g., Daconil, Bravo), chlorothalonil + fenarimol (e.g., TwoSome), thiophanate methyl (e.g., Cleary's 3336), and copper sulphate pentahydrate (e.g., Phyton 27);
  - the labels contain information on dosage rates and safety precautions;

- applications can be made when new shoots emerge and are continued as necessary, since additional applications may be necessary in years with excessive rainfall.

<u>PHYTOPHTHORA ROOT ROT</u>

Causal Agent: *Phytophthora* spp. (fungus-like organism)

Key Hosts: most conifers, especially true firs such as Fraser fir

Symptoms and Spread:

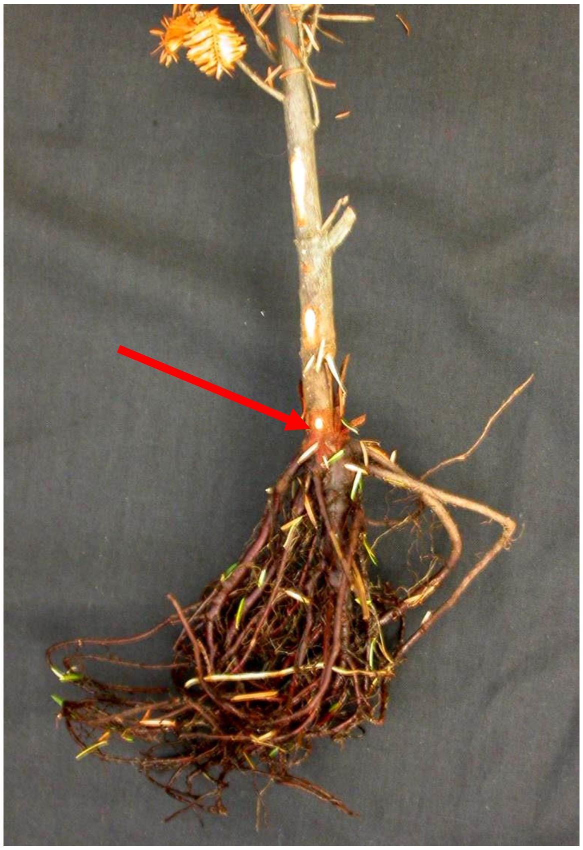
Wet sites provide optimum conditions for this disease, especially on highly susceptible species like Fraser fir.

Aboveground symptoms of Phytophthora root rot are not very distinctive and is a characteristic typical of most root rot diseases. Included among the symptoms are suppressed growth, poor vigor, yellowed or undersized needles, premature needle drop, branch dieback, wilt, and death of trees at any time during the season.

Diagnostic symptoms can usually be seen at the base of the infected tree, either as extensive resin-flow on the outer bark or cracking in the root-crown area. A characteristic and distinctive cinnamon-brown discoloration is usually evident when cuts are made into the wood in this area.

Aboveground symptoms of Phytophthora root rot are not distinctive.

Phytophthora root rot is often associated with drainage problems and wet sites. This soil borne pathogen (previously called a “water mold”) produces motile spores that readily move in water. Therefore, declining trees often follow drainage patterns in plantations, especially those sited on hills: an infected tree at the top of the drainage pattern can effectively inoculate the trees below. Chlamydospores or oospores, are formed in infected roots, and enable the pathogen to survive in the soil between crops or during unfavorable periods. When these dormant structures are subjected to warm and saturated soils, even for a few hours, this pathogen can be activated.



Red-brown discoloration of the cambium tissue (arrow) of Fraser fir infected by *Phytophthora*, contrasted with white, healthy cambium.

Root rot can be severe in young Christmas tree plantations since young, newly planted trees are the most susceptible.

Fortunately, trees become more resistant, but not immune, with age. Phytophthora root rot can also be a problem in seedling and transplant beds. When seedlings are infected, the roots appear distinctly cinnamon brown in color and lack feeder roots. Refer to the fact sheet *Diseases of Christmas Tree Seedling and Transplant Beds* for more details.

Management:

- Use healthy stock. Carefully inspect transplants from seedling beds prior to planting.
- Avoid planting in poorly drained sites or take steps to modify or improve drainage.
- Maintain vigor by proper fertilization (based on soil tests) and planting practices; avoid excessive irrigation.
- Rogue and remove symptomatic trees.
- Select resistant species such as Canaan, Grand, Nordemann, and Turkish firs in place of highly susceptible Fraser fir.
- Fungicides:
    - ***NOTE:* Fungicides are not curative**--infected trees cannot be cured.
    - healthy, uninfected plants adjacent to symptomatic plants can be *protected* with fungicides; fosetyl-Al (Aliette), mefenoxam (Subdue MAXX), and phosphorous acid or mono- and di-potassium salts of phosphorous acid (Alude, Magellan, Fosphite);
    - refer to the label for information on dosage rates and safety precautions.

Sporangia of *Phytophthora* produce motile spores (zoospores) that swim in surface runoff or in irrigation water.

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Dr. Sharon M. Douglas
The Connecticut Agricultural Experiment Station
Department of Plant Pathology and Ecology
123 Huntington Street, P.O. Box 1106
New Haven, CT, 06504

E-mail: Sharon.Douglas@ct.gov
Phone: (203) 974-8496
(203) 974-8601
Website: www.ct.gov/caes

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The Connecticut Agricultural Experiment Station
Putting Science to Work for Society since 1875

Dr. Sharon M. Douglas
Department of Plant Pathology and Ecology
The Connecticut Agricultural Experiment Station
123 Huntington Street, P. O. Box 1106
New Haven, CT 06504

Phone: (203) 974-8601
Fax: (203) 974-8502
Email: Sharon.Douglas@ct.gov
Website: www.ct.gov/caes

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SLIME MOLDS

Slime molds are highly conspicuous organisms that can "magically" appear overnight on mulch, plants, and turf. The rapid and unexpected appearance of these nuisance organisms is frequently a cause for misdirected alarm. Slime molds have also been the source of countless stories, myths, and colorful names such as the "blob" and the "dog vomit fungus."

Slime molds are classified in the Kingdom Protista (the Protists), despite many years of having been classified as fungi, in the class Myxomycetes. This change in classification resulted from research that yielded new information about their biology and phylogeny. The most common classification system places slime molds in two phyla: Phylum Myxomycota and Phylum Acrasiomycota. The Myxomycota are the true (plasmodial) slime molds and the Acrasiomycota are the cellular slime molds.

DESCRIPTION:
Since there are over 700 different types of slime molds, the shape, structure, and color can be quite variable. They are found on wood chip mulches, lawns, garden beds, on herbaceous and woody ornamental plants, and even creeping up foundation walls of buildings and other structures. Slime molds are most prevalent after periods of wet, moderate temperatures in the fall and spring. Many slime molds on wood chip mulches are brightly colored masses. One of the most common slime molds on mulch is *Fuligo septica.* It can appear as a bright yellow, orange, or creamy, irregular mass, ranging from one inch to several feet in diameter (Figures 1 and 2).

Figure 1. Creamy-colored *Fuligo septica* growing on shredded bark mulch.

In lawns, the presence of a slime mold gives the grass a bluish-gray to purple-brown appearance from a distance. These areas can be patchy and can be as large as several feet in diameter. Upon close inspection, individual grass blades are covered by the purple-brown mass of the slime mold (Figure 3). One of the common slime molds on turf in Connecticut is *Physarum.*

Figure 2. Yellow *Fuligo septica* growing on s bark mulch.

Slime molds can also be found on woody and herbaceous plants, especially on the portions of the plants that are closest to the ground. It is not unusual to see the lower branches of a rhododendron or juniper coated with the colorful mass of a slime mold.

Figure 3. Slime mold growing on grass blades.

Slime molds are not pathogenic to plants, although they occasionally cause indirect injury. This occurs when they cover and shade plant tissues for extended periods and inhibit photosynthesis. Slime molds have no direct economic importance.

Slime molds are cosmopolitan organisms that feed on bacteria, fungi, protozoa, and other tiny organisms. Their life cycle is similar to those of true fungi. Perhaps this is one of the reasons why they were classified as fungi for many years. A generalized life cycle for the slime molds commonly found in Connecticut consists of two phases. Slime molds reproduce by spores, which can remain dormant in soil for many years. During periods of moderate temperatures and moist conditions, the spores germinate and release small, motile cells. Two of these amoeba-like cells fuse together and form a shapeless, growing mass called a plasmodium. A plasmodium is a multinucleate mass of protoplasm that results from the fusion. Plasmodia can be colorless, gray, cream, bright yellow, or orange. This is a feeding and “creeping” stage of the organism, so when sufficient water is available, slime molds creep or flow over many types of surfaces. They creep at a relatively fast pace and can move several feet in 24 hours. When environment conditions become drier and warmer, they are no longer favorable for this stage of the slime mold. At this point, the slime mold undergoes a remarkable metamorphosis. As it dries up, it transforms from a shapeless plasmodium to an organized structure called a sporangium. This is the more conspicuous and recognizable “blobby” mass previously described. It is during this stage that spores are formed and the cycle starts to repeat.

Growth of slime molds is favored by relatively cool, moist, shady conditions. However, slime molds can readily grow in open, sunny locations. Since moisture and temperature seem to be the most important factors associated with the occurrence and prevalence of these organisms, slime molds are often more abundant during or after periods of moderately cool, wet weather, especially in spring and autumn. Slime molds have been more prevalent in landscape situations during the past 10 years—this may be associated with weather patterns and the increased popularity and use of wood mulches.

STRATEGIES FOR CONTROL:
Since slime molds are not pathogenic to plants and are considered curiosities and nuisances, proactive control is not necessary. However, these organisms can be quite unsightly, so removal of the structures is often the preferred way of dealing with them. When slime molds develop on mulch, the structures can be removed with a shovel or disturbed by raking. When they grow on plants and turf, slime molds can be removed with a forceful spray of water from a hose. On turf, slime molds can also be effectively removed by mowing. However, if left alone, slime molds will eventually dry up, turn powdery, and disappear.

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Dr. Sharon M. Douglas
Department of Plant Pathology and Ecology
The Connecticut Agricultural Experiment Station
123 Huntington Street, P. O. Box 1106
New Haven, CT 06504

Phone: (203)974-8601
Fax: (203) 974-8502
Email: Sharon.Douglas@po.state.ct.us

SOLVING ABIOTIC TREE PROBLEMS

While tree problems attributed to **cultural and environmental factors** are common, they are becoming increasingly more common as populations increase and urbanization continues. In many cases there is little that can be done about these problems once they are observed so **prevention** is usually the best approach.

I. STRESS PROMOTING ELEMENTS:

A. Acute-

these are stresses that occur suddenly and cause damage soon after;
examples: improper pesticide sprays, frosts, freezes, injuries during transport

B. Chronic-

these are stresses that occur gradually and appear as a general decline;
examples: nutritional imbalances, improper pH of the soil, too low light

II. COMMON ENVIRONMENTAL PROBLEMS:

A. Meteorological Effects:

1. Frost-

a. Symptoms:

quite variable, depending upon time of damage; includes twig and branch dieback, bark cracking or splitting, leaf distortion; frozen tissues can turn blackish brown

b. Causal Factors:

damage can occur in late spring, early fall, and during dormancy; dormant frost damage can result in failure to leaf out

2. Sunscald/Sunscorch-

a. Symptoms:

variable, including bark splitting and leaf scorch; new growth of ornamentals may be affected under extremely high temperatures; often occurs on the southwest side of the tree during winter or early spring ("southwest injury")

b. Causal Factors:

periods of extremely high temperature combined with windy conditions; often a combination of above freezing temperatures during the day and freezing temperatures at night

3. Light-

a. Symptoms:

poor growth and vigor; undersized, off-colored leaves or needles; lower branch dieback is common

b. *Causal Factors:*

incorrect light level for tree species

4. Lightning-

a. *Symptoms:*

trunk shattering, splitting of bark and canopy dieback; a long slash up the cambium spiralling down the tree where a 1-4 inch wide strip of bark has been ripped off; long splinters of wood at base of tree

b. *Causal Factors*

lightning charge follows the most conductive path between top and roots, sometimes along the surface but often in outer sapwood

5. Winter Injury-

a. *Symptoms:*

dieback, foliar browning, sunscald, and bark splitting

b. *Causal Factors:*

late spring frosts (after growth has started), cool summer followed by a warm fall and drop in temperature, excessive or late season nitrogen fertilization, dry soil or root injury, frost cracking, excessive temperature fluctuations and drying winds, lack of snowcover

c. *Commonly Affected Plants:*

wide range of plants including broadleaved evergreens (rhododendron and mountain laurel), narrowleaved evergreens (arborvitae, yew, juniper, pine, and hemlock), deciduous trees and shrubs (weeping cherry, rose), and ground covers (pachysandra and ivy)

d. *Control Measures:*

1. select appropriate site for planting
2. have sufficient moisture in root zone before soil freezes
3. avoid late summer and early fall fertilization
4. mulch to increase moisture retention in winter
5. prune out dead branches or twigs in spring and fertilize to stimulate new growth
6. use of anti-transpirants or anti-desiccants

B. Air Pollution:

1. *Symptoms:*

highly variable, depending upon type of pollutant and plant host; typically classified as **acute** or **chronic**; **acute injury** normally involves the death of cells and develops within a few hours or days following exposure to high levels of pollutants; symptoms include stippling or altered pigmentation, flecking, bleaching, chlorosis, interveinal and marginal necrosis, and tip necrosis; **chronic injury** typically develops more slowly, within days or weeks following exposure; this type of injury usually appears in response to long-term, low-concentration exposure; in some cases, visible symptoms are not present but exposure results in suppressed photosynthesis rates, stimulated respiration, and suppressed growth; symptoms are often subtle and easily confused with other problems such as normal senescence, nutritional disorders or other environmental stresses

2. *Causal Factors:*

   major classes of phytotoxic air pollutants, in descending order of direct damage are: oxidants (ozone O_3, PAN), sulfur dioxide (SO_2), and fluorides (hydrogen fluorides HF)

3. *Commonly Affected Plants:*

   significant differences in sensitivity of plant species to specific pollutants occur; particularly sensitive tree species to specific pollutants are:

   O_3-- white ash, eastern white pine, black cherry, catalpa, honey locust

   SO_2-- larch, birch, American elm, eastern white pine

   HF-- young, expanding needles of pines and spruces, paulownia, Douglas fir, serviceberry

4. *Control Measures*

   a. plant resistant or tolerant species where pollutants are known problems

   b. maintain good plant vigor by proper cultural practices

C. Water Problems:

1. **Drought-**

   a. Symptoms:

   loss of turgor in needles or leaves, drooping, wilting, yellowing, premature leaf or needle drop, dieback, poor growth, stunting, plant death; predisposes plant to secondary problems and cultural injuries; symptoms often not evident until the year after drought occurs

   b. Causal Factors:

   soil water becomes deficient and results in feeder root damage and death; plant unable to take up water

   c. Commonly Affected Plants:

   broad range of deciduous and evergreen trees and shrubs; effects are particularly severe on seedlings or recent transplants but established plants are also affected; especially affected this year were maple, ash, hemlock, juniper, dogwood, rhododendron

   d. Control Measures:

   1. water in periods of low soil moisture
   2. select appropriate site and use proper planting practices
   3. select native plants adapted to local seasonal and annual variations in the water supply; drought sensitive (e.g., dogwood, many oaks, arborvitae, many *Viburnum*) vs drought tolerant species (e.g., most pines, many *Prunus*, eastern larch, some junipers)
   4. prune out dead branches or twigs in spring

2. **Excess Water-**

   a. Symptoms:

highly variable, including epinasty (downward bending of petioles), stem swelling, chlorosis, edema, reduced and stunted growth, twig dieback, wilting, leaf drop, root and plant death

b. Causal Factors:

root damage in flooded or waterlogged soils is associated with oxygen deficiency; damaged fibrous roots die, decay, and plants are unable to take up water; predisposed plants are subject to secondary invaders and opportunistic pests

c. Commonly Affected Plants:

seedlings and new transplants are more sensitive than established ones; dormant plants tolerate flooding longer than those in active growth; angiosperms are generally thought to be more tolerant than gymnosperms; particularly affected are yews, hemlocks, maples, rhododendrons

d. Control Measures:

1. avoid plant stress by appropriate site selection and proper planting practices
2. maintain vigor by fertilization to stimulate good growth
3. select appropriate species for site and soil conditions, water-tolerant species (e.g., red maple, eastern larch, forsythia, green ash) vs water-intolerant species (e.g., gray and paper birch, crabapple, dogwood, eastern hemlock)
4. prune dead or dying tissues to minimize problems from secondary invaders

D. Soil Modification:

Trees are affected by many types of mechanical and chemical injuries and symptoms often do not show up until considerably after the damage has been done and often not until it is too late to save the tree; these injuries can result in significant damage the root system;

1. Mechanical-

a. Construction Injuries:

- "Bulldozer Blight" often damaging the base of the trunk

b. Soil Compaction (Root Smothering):

- roots are crushed by driving heavy construction equipment or trucks over roots

c. Root Cutting:

- roots are cut when excavating for foundation walls, sidewalks, or streets

2. Chemical-

a. Salt:

- salt damage results from both direct sprays and from absorption through roots; one type of damage results from coastal flooding with salt water; a second type is associated with de-icing salts which cause damage to roots when they buildup and leach into soil and damage foliage and branches when salt-containing water form the "spray zone" comes in direct contact with plant tissues

b. Excess Fertilizer:

- often results from over-application of lawn fertilizers and can cause excessive levels of soluble salts and subsequent root damage

*c. **Natural Gas:***

- gas leaking into the soil induces anaerobic conditions; microorganisms in the soil transform sulphates to hydrogen sulfide which inhibits respiration by the roots and nutrient uptake

*d. **Herbicide:***

- careless or misapplied herbicides, most frequently associated with lawn applications of broadleaf weed killers such as 2,4-D or dicamba in root zones of woody ornamentals

E. Mechanical Injuries:

These types of injuries result in direct physical damage to the tree and cause a variety of symptoms from canopy thinning to tree death.

1. Lawnmower, String Trimmer
2. Storm / Wind Damage
3. Snow and Ice Damage
4. "Human" Damage

V. NUTRITIONAL PROBLEMS:

Although considerable research has been conducted in order to understand nutrient imbalances associated with toxicities and deficiencies, the effects of either extreme are ***very*** difficult to diagnose. In many cases, soil and plant tissue analyses are necessary for accurate diagnosis. Symptoms of imbalance may appear on all or any parts of the tree but are most common on foliage. In some cases, nutrients may be present in the soil but are unavailable for uptake by the tree due to many factors including soil pH problems, competition with other ions, and root damage.

A. Deficiencies
B. Toxicities

VI. ANIMAL DAMAGE:

Animals can cause significant damage to woody ornamentals in urban, suburban, and rural settings; damage results in a variety of symptoms from decline to sudden death.

A. Squirrels
B. Voles / Meadow Mice
C. Deer

VII. OTHER PROBLEMS:

Trees are subject to so many other problems they are too numerous to mention. However, two common cultural problems are worth mentioning.

A. Girdling Roots
B. "Flower Disease"

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Dr. Sharon M. Douglas
Department of Plant Pathology and Ecology
The Connecticut Agricultural Experiment Station
123 Huntington Street, P. O. Box 1106
New Haven, CT 06504

Phone: (203) 974-8601
Fax: (203) 974-8502
Email: Sharon.Douglas@ct.gov
Website: www.ct.gov/caes

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SPHAEROBOLUS SPP.--THE ARTILLERY FUNGUS

The presence of persistent brown to black spots on cars, house siding, plants, and other surfaces may be an indication of the presence of the fungus *Sphaerobolus* spp. These brown spots are spore masses called peridioles or glebal masses, which are approximately 1-2 mm (1/12 inch) in diameter. They are the dispersal structures of *Sphaerobolus.* This fungus is a Basidiomycete and a member of the class Gasteromycetes, family Sphaerobolaceae. (However, molecular data now suggest that this species might be better placed in the family Geastraceae)

Sphaerobolus is a cosmopolitan saprophyte (decay organism) found on wood and bark chips, dead and decaying wood, and dung and is not considered a pathogen of plants, animals, or humans. The increased prevalence of this fungus during the past ten years appears to be partly associated with the increased popularity and use of bark and wood chip mulches in the landscape.

Sphaerobolus is commonly called the "artillery fungus" or "sphere thrower" since it forcibly ejects its spore masses (called peridioles or gleba) for considerable distances. Peridioles can be projected vertically for more than 2 m (6 ft) and horizontally for over 6 m (20 ft). Some researchers have also reported that the discharge is accompanied by an audible sound. As with most fungi, growth of *Sphaerobolus* is influenced by temperature, light, and moisture. It grows better under wet conditions and is most commonly a problem during the cool, wet conditions of spring and fall. It is much less problematic during the hot, dry periods of midsummer. For much of its life, this fungus consists of a mass of white, thread-like filaments called hyphae, which aren't readily visible to the naked eye (Figure 1).

Figure 1. Magnified view of white, thread-like filaments (hyphae) (arrows) of *Sphaerobolus* growing on wood chips.

However, the presence of this growth can sometimes be recognized as matted or gray, somewhat bleached areas in a mulch bed. This bleaching is attributed to the digestion of the lignin, cellulose, and hemicellulose in the wood, as it is colonized by the fungus.

Fruiting structures (called basidiocarps) usually form on substrates (wood chips, bark, dung, or decaying plant material) in autumn and spring. They are small, spheres approximately 1-2.5 mm (1/10 inch) in diameter and buff to yellow in color (Figure 2). Because of their size, they are very difficult to find in the mulch.

Figure 2. Early stages of developing basidiocarps (arrow).

As the fruiting structures mature, outer walls of the basidiocarps rupture, giving the structures a star or nest-like appearance. As they open, the peridioles or gleba are visible as dark masses at the bottom of the opening structures (Figure 3). Increases in osmotic pressure, possibly due to the conversion of glycogen to sugars, cause the membranes under the peridioles to swell and turn inside out. This process provides the force (estimated to be 1/10,000 horsepower) to propel or eject the peridioles into the air. After the peridioles are discharged, the swollen, inner membranes remain visible as glossy protrusions in the basidiocarps (Figure 4). These fruiting structures usually remain active or "shoot" for approximately 2-3 weeks .

Figure 3. Basidiocarps splitting to form star-like "nests." Note the peridioles (dark objects at bottom of each "nest") before they are shot.

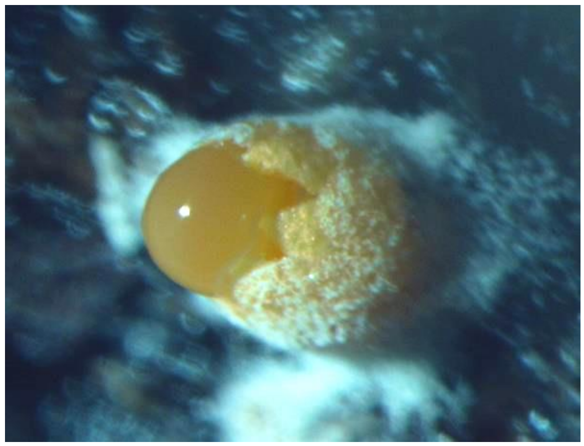

Figure 4. The glossy protrusion visible after the peridioles are discharged.

Adequate light and moisture are also necessary for ejection or discharge of peridioles. The ejection process is phototropic, which means that the peridioles are projected towards light and light-colored objects (e.g., white cars, beige houses). Peridioles are typically quite sticky and, since they are forcibly ejected, they readily adhere to objects upon which they are impacted (Figures 5 and 6).

Figure 5. *Sphaerobolus* spp. growing on wood chips in a petri dish. Note the brown peridioles shot onto the lid.

Figure 6. Close-up of peridioles stuck to the lid of plastic petri dish after being shot from fruiting bodies. Note the flattened appearance due to impact and the sticky halo of material adhering the peridiole to the surface.

When the peridioles dry, they become *very* difficult to remove (Figure 7). Unfortunately, *Sphaerobolus* can be long-lived and peridioles have been found to still be viable for up to 12 years. In addition to growing on wood and bark mulches, *Sphaerobolus* hyphae and peridioles can also be dispersed by wind or over long distances in plant debris, mulch, animal fur, and animal dung.

Questions about sources of *Sphaerobolus* are common and very difficult to answer. Since the fungus commonly occurs on many substrates in forests, woodlots, and home landscapes, it is impossible to pinpoint or definitively "prove" or identify the source.

Figure 7. Peridioles stuck on an aluminum vent located on the side of a house.

MANGEMENT STRATEGIES:

Prevention and avoidance are the major strategies for managing this fungus, since chemicals have not been found to be effective. Management strategies focus on the substrate (e.g., mulch) that supports the growth of *Sphaerobolus*. This involves removing or disturbing the wood chips or bark mulch with a rake to disperse the fungus and to dislodge the fruiting bodies. This also helps to dry out the mulch by increasing air circulation and creating conditions that are less favorable for the growth and sporulation of the fungus. Periodically overlaying existing mulch with fresh mulch reduces the light necessary for peridiole discharge and has been successful in some situations. However, when overlaying, it is important to avoid making the mulch layer too thick, since this can be detrimental to the health of any plants in the mulched beds.

The type of mulch used is also an important strategy for managing this problem. It is important to select mulches that contain ***at least 85% bark***. *Sphaerobolus* will not grow as well on bark as on wood, since bark is a less favorable source of carbon than wood. This has become an issue of concern since today, a substantial amount of the mulches used are made from recycled wood or from chipped tree prunings (e.g., branches, trunks), that are comprised mainly of wood. As a consequence, these mulches provide better sources of carbon than the previously used mulches that contained mainly bark. Today's mulches are also more finely-shredded than previously, so these mulches probably hold more moisture than the older, coarsely ground mulches—conditions that favor growth of *Sphaerobolus*, since moisture is necessary for its survival.

All types of mulch can potentially support the growth of this fungus. However, research has determined that large pine bark nuggets tend to remain hard and dry so they are less favorable for growth of the fungus than other types of mulch. Additionally, cypress mulches appear less favorable for growth.

Another tactic to minimize *Sphaerobolus* problems in the landscape is to use an alternative (inorganic) form of mulch. These include black plastic, stone, pea gravel, or marble chips. These types of mulch are best used in areas directly adjacent to homes, cars, or other surfaces where the risk of damage is the greatest.

Sphaerobolus can occasionally be a problem in container-grown plants when bark or wood products are components of the potting media. It has been suggested that composting the bark or wood products prior to use may help to reduce the ability of the artillery fungus to colonize the wood or bark by promoting the growth of beneficial organisms that are antagonistic to it.

Peridioles should be removed from affected surfaces with a stiff water spray from a hose or by scrubbing with a wet cloth or stiff brush **before they dry**. Unfortunately, in most cases, this is not practical and removal is usually attempted **after the peridioles have dried**. When this is the case, they are ***very difficult to remove*** and must be physically scrubbed and scraped from the affected surfaces.

When the glebal masses are on glass surfaces, they can be easily removed by scraping with a razor blade. However, care must be exercised when removing the hardened masses from other surfaces, since the removal process itself can often damage the substrate.

When removing the brown dots or peridioles, one must take into account the fact that they can remain viable for more than 10 years and can serve as a means for spreading the fungus. As a consequence, peridioles should be carefully scraped off affected surfaces. The peridioles will not grow on house siding or inert substrates such as concrete or paved walkways. However, if they fall into mulch or another suitable organic substrate, they can germinate and re-infest these substrates. A tarp or similar item should be placed under the area that is being scraped to catch the fungal structures as they drop in order to keep them from re-infesting the substrate.

Extensive staining can also remain after the fungal masses are removed. These stains usually fade with time but can be unsightly. Pitting of the substrate has also occasionally been observed, especially on cars. Power washing (and double power washing with a rigorous scrubbing in between) has yielded mixed results and its success appears to be dependent upon the particular type and age of the siding. More effective results have been obtained with new vinyl siding whereas limited success has been reported for old vinyl, aluminum, and older painted wood siding.

May 2010 (revision)

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Dr. Sharon M. Douglas
Department of Plant Pathology and Ecology
The Connecticut Agricultural Experiment Station
123 Huntington Street, P. O. Box 1106
New Haven, CT 06504

Phone: (203) 974-8601
Fax: (203) 974-8502
Email: Sharon.Douglas@ct.gov
Website: www.ct.gov/caes

SPRUCE NEEDLE RUSTS IN CONNECTICUT

Although at least ten different rust fungi (*Chrysomyxa* spp.) have been reported on spruce in the United States, the key needle rusts of concern for Christmas tree growers in Connecticut at present are caused by *C. ledi*, *C. ledicola*, and *C. weirii*. *C. weirii* is considered to be a relatively new problem since its first appearance with any severity and frequency in 1996. However, this rust has undoubtedly been present in the state prior to 1996. *C. weirii* has also been reported in Pennsylvania, Vermont, New Hampshire, and New York and appears to be on the increase. This fact sheet serves as an update on the status of this and other needle rusts in Connecticut. Accurate diagnosis is critical and requires microscopic identification of the symptomatic needles. It is important to know which particular rust you have since this will determine how the disease spreads and the types of control measures that are effective.

One of the key features used to distinguish the needle rust caused by *Chrysomyxa weirii* from all other needle rusts is the fact that it is **autoecious**. This means it does not require an additional host or hosts in order to complete its life cycle. The other *Chrysomyxa* needle rusts are **heteroecious** and require more than one host to complete their life cycles. For example, the alternate hosts for *C. ledi* are Labrador tea and leatherleaf. This feature is important since it determines the types of strategies that are effective for disease management.

I. AUTOECIOUS SPRUCE NEEDLE RUST

1. Causal Agent: *Chrysomyxa weirii* (fungus)

2. Key Hosts: white, black, and blue spruce

3. Symptoms and Spread:

This needle rust is autoecious and does not require any additional hosts in order to complete its life cycle. Infected trees are rarely killed but the primary damage results in extensive needle discoloration and drop which reduces the marketability of the infected trees.

Symptoms first appear as yellow spots or flecks on needles in late winter and early spring (Figure 1). These spots eventually develop into pustules or blisters (telia) and burst open to reveal masses of yellow-orange spores (teliospores) (Figures 2, 3, and 4). The teliospores then produce another type of spore (basidospores), which are readily blown by wind and splashed by rain onto needles of the same tree or onto those of adjacent trees (Figure 5). Infection occurs when needles first emerge and are tender and immature. The following spring, yellow spots and blisters develop on the infected needles and the disease cycle starts again. Blisters of *C. weirii* can appear on both 1st and 2nd year needles and heavily infected trees can appear distinctively yellow-orange from a distance. Accurate diagnosis requires microscopic examination since symptoms may easily be confused with those caused by other needle rusts. As with most diseases that are not fatal but result in needle drop, repeated defoliation may retard growth and reduce marketability.

Figure 1. Yellow spots or flecks develop on needles in late winter and early spring.

Figure 2. Diagnostic rust symptoms on one-year needles in spring, before new growth has emerged.

Figure 3. Rust spores blown by wind and splashed by rain onto newly emerging needles.

Figure 4. Close-up of rust pustules.

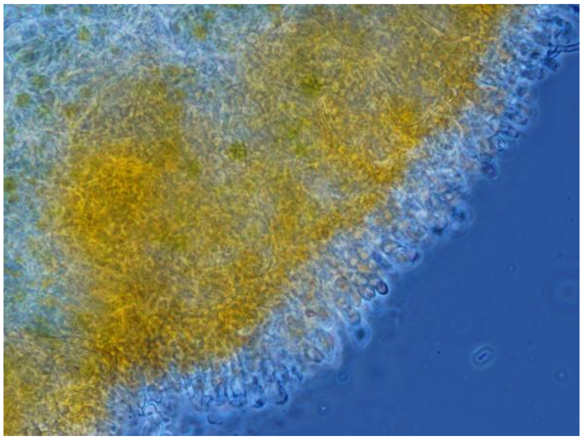

Figure 5. Photomicrograph of rust spores developing in pustules on one-year-old spruce needles.

4. Control:

a. Use healthy stock and maintain tree vigor.

b. Rogue and remove heavily infected trees to reduce inoculum.

c. Fungicide sprays.

- in all cases, **coverage and timing** are **very** important;
- although rust is not specifically listed on the label, chlorothalonil (Daconil 2787, Bravo, Thalonil) is labelled for spruce and is effective for control;
- the label contains information on dosage rates and safety precautions;
- the first application should be made when 10% of the trees have broken some buds; applications should then be made at weekly intervals until needles are mature or until symptomatic needles have dropped to the ground; this is usually 3 sprays but in years where bud break is slow and the weather is cool and wet (this spring), up to 5 sprays may be necessary;

II. HETEROECIOUS SPRUCE NEEDLE RUSTS

1. Causal Agent: *Chrysomyxa ledi and C. ledicola* (fungi)

2. Key Hosts: white, black, and blue spruce

3. Symptoms and Spread:

These needle rusts are caused by fungi that require more than one host in order to complete their life cycles: the primary hosts are spruce and the alternate hosts are two shrubby evergreen members of the Heath family, Labrador tea (*Ledum groenlandicum*) and leatherleaf (*Chamaedaphne calyculata*). Therefore, these diseases are often first evident in stands located near swamps or wet areas where the alternate hosts are present. Infected trees are rarely killed but the primary damage results in needle loss which renders the trees unfit for sale.

Symptoms on spruce first appear as whitish blisters (aecia) on the surface of the current season's needles in mid-summer. These blisters burst open and reveal distinctive yellow-orange spores (aeciospores) which are readily wind-blown to the alternate hosts in the summer. Once on the alternate hosts, the fungal spores germinate and infect the leaves in which the fungus overwinters. The following spring, white blisters or pustules (telia) develop on the lower surfaces of the infected leaves and rupture the epidermis. Distinctive, yellow-orange spores (teliospores) germinate and produce another type of spore (basidiospores), which are released and carried by the wind to infect newly emerging and developing spruce needles. By mid-summer, symptoms are evident on the current season's needles and the disease cycle starts again. Symptoms on heavily infected trees can be quite dramatic as the trees appear golden yellow from a distance. Infected needles usually die and are cast by late summer--in severe cases, trees can lose up to 90% of their new needles. While spruce needle rust is not considered fatal, repeated infections may retard growth and reduce marketability.

4. Control:

a. Use healthy stock and maintain tree vigor.

b. Avoid planting susceptible spruce trees near swampy areas where the alternate hosts may be prevalent.

c. Roguing and removing diseased trees *may* help to reduce inoculum.

d. Use resistant species, if possible.

- Norway and Black Hills spruce are fairly resistant.

e. Fungicides are essentially ineffective for control.

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Dr. Sharon M. Douglas
Department of Plant Pathology and Ecology
The Connecticut Agricultural Experiment Station
123 Huntington Street, P. O. Box 1106
New Haven, CT 06504

Phone: (203) 974-8601
Fax: (203) 974-8502
Email: Sharon.Douglas@ct.gov
Website: www.ct.gov/caes

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THE *ON-LINE* PLANT PEST HANDBOOK
www.ct.gov/caes

The Experiment Station published its first report on effective and practical ways to control plant diseases in 1889. In the many years that followed, Station scientists have published hundreds of scientific reports on all aspects of plants and agriculture. These have appeared in many different forms and forums but one source of information that many Connecticut residents, homeowner or farmer, urbanite or suburbanite, have found particularly useful has been the *Plant Pest Handbook*. The first *Plant Pest Handbook* was published in two volumes in 1933 and 1934. The most recent edition of the *Handbook* was published in 1956 and many, well-used copies can still be found on bookshelves throughout the state!

In 2001, we were pleased to present a new version of the *Handbook*- this time in electronic form. The *On-Line Plant Pest Handbook* had been totally updated to reflect changes in the plants that are now grown in Connecticut and their current disease and insect problems. The new *Handbook* had also been updated to emphasize a "Plant Health Management" or "Integrated Pest Management" approach to dealing with plant pests and their impact. Among the many key features of this electronic version were:

- Easily updated as new diseases or pests appear or as new information about a particular pest becomes available;
- Easily updated as pesticide registrations or availability change;
- Highly interactive since it allows seamless access to additional information posted in other areas of the Experiment Station Website such as fact sheets on particular problems and email addresses of people to contact for more information or questions;

The *On-Line Handbook* is also dynamic. We will probably always consider this a "work-in-progress" that is continually being updated. Today, we are in the process of updating the handbook by editing text, adding new information, and incorporating suggestions from users of the *Handbook* from Connecticut as well as from national and international origin. A key objective is to add more color photos. This should greatly enhance the usefulness of the *Handbook* for all users.

Although the *Handbook* is electronic, it is important to remember that any section of the *Handbook* can be printed. For example, you can look up a plant and print a copy of that particular section for further reference.

HOW IS THE HANDBOOK ORGANIZED?

The *Handbook* is organized into four sections.

A. Introduction-

- This section provides a brief description of the *Handbook* and lists the Station Scientists who contributed sections.

B. Plant Health Problems-

- This section provides an introduction to plant diseases, general background information on plant pathogens, and strategies for management and control.

C. Insects and Their Injuries to Plants-

- This section provides an introduction to insects, their injuries to plants, and general background information.

D. Search by Host-

- This section provides an alphabetical listing of plants by their common name; there are over 240 plant hosts covered in the *Handbook.*
- Once you select the plant, you will see a listing of all of the key pest problems on that particular host in Connecticut.

WHAT TYPE OF INFORMATION IS LISTED FOR EACH HOST PLANT?

- **Plant Health Problems-**
    - arranged by importance within each pathogen type (diseases caused by fungi, fungus-like organisms, bacteria, phytoplasmas, viruses, and nematodes);
    - physiological and environmental problems are also covered;
    - each section about a plant health problem provides information on symptoms and on how to manage or minimize the impact of that problem;when available, hot links will bring you to additional information (e.g., fact sheets) on that topic that is posted in other areas of the Experiment Station web site;
- **Insect Problems**
    - arranged alphabetically within host; each section about an insect provides information on damage and on how to manage or minimize the impact of that pest; when available, hot links will bring you to additional information (e.g., fact sheets) on that topic that is posted in other areas of the Experiment Station web site;

HOHOW CAN THE HANDBOOK BE IMPROVED?

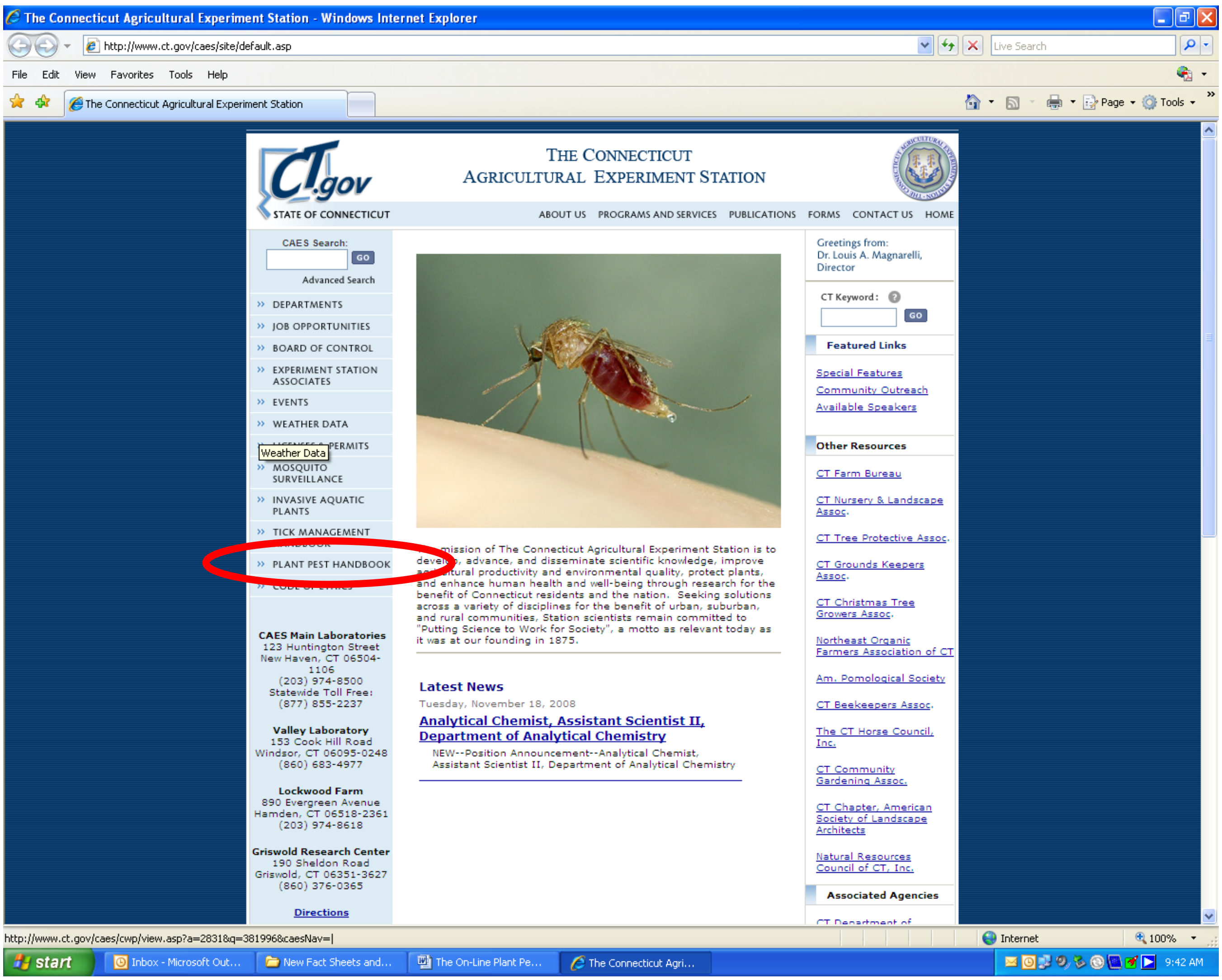
The *Handbook* is not all-inclusive with regard to plant hosts and pests. However, efforts were made to address the most common plants grown in Connecticut and their key pests. We welcome comments and suggestions for improving this resource at any time.

Website screens can be found on the next pages.

December 2008 (revised)

The Connecticut Agricultural Experiment Station Website:

www.ct.gov/caes



Plant Pest Handbook Homepage


CAES: Plant Pest Handbook--A Guide - Windows Internet Explorer

http://www.ct.gov/caes/cwp/view.asp?a=2826&q=378182&caesNav=|

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123 Huntington Street
New Haven, CT 06504-1106
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Statewide Toll Free:
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Valley Laboratory
153 Cook Hill Road
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(860) 683-4977

Lockwood Farm
890 Evergreen Avenue
Hamden, CT 06518-2361
(203) 974-8618

Griswold Research Center
190 Sheldon Road
Griswold, CT 06351-3627
(860) 376-0365

Directions

Plant Pest Handbook--A Guide

A guide to insects, diseases, and other disorders affecting plants

Prepared by:
The Connecticut Agricultural Experiment Station

Edited by:
Dr. Sharon M. Douglas
Dr. Richard S. Cowles

Special Thanks to:
Sandra Carney

INTRODUCTION
Description of the Plant Pest Handbook

PLANT HEALTH PROBLEMS
Introduction to plant diseases and and strategies for management and control

INSECTS AND THEIR INJURIES TO PLANTS
Introduction to insects and their injuries to plants

SEARCH BY HOST PLANT
Select a plant and find information on its pests

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Printable Version

Dr. Sharon M. Douglas
Department of Plant Pathology and Ecology
The Connecticut Agricultural Experiment Station
123 Huntington Street, P. O. Box 1106
New Haven, CT 06504

Phone: (203) 974-8601
Fax: (203) 974-8502
Email: Sharon.Douglas@ct.gov
Website: www.ct.gov/caes

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VERTICILLIUM WILT OF ORNAMENTAL TREES AND SHRUBS

Verticillium wilt is a common disease of a wide variety of ornamental trees and shrubs throughout the United States and Connecticut. Maple, smoke-tree, elm, redbud, viburnum, and lilac are among the more important hosts of this disease. Japanese maples appear to be particularly susceptible and often collapse shortly after the disease is detected. Plants weakened by root damage from drought, waterlogged soils, de-icing salts, and other environmental stresses are thought to be more prone to infection.

Verticillium wilt is caused by two closely related soilborne fungi, *Verticillium dahliae* and *V. albo-atrum*. Isolates of these fungi vary in host range, pathogenicity, and virulence. *Verticillium* species are found worldwide in cultivated soils. The most common species associated with Verticillium wilt of woody ornamentals in Connecticut is *V. dahliae*.

SYMPTOMS AND DISEASE DEVELOPMENT:

Symptoms of Verticillium wilt vary by host and can be characterized as acute or chronic. Plants or branches with acute infections may wilt and die suddenly (Figure 1).

Figure 1. Japanese maple with acute symptoms of Verticillium wilt.

They also develop a variety of symptoms that include wilting, curling, browning, and drying of leaves. These leaves usually do not drop from the plant. In other cases, leaves develop a scorched appearance, show early fall coloration, and drop prematurely (Figure 2).

Plants with acute infections start with symptoms on individual branches or in one portion of the canopy. This symptom is often called “flagging.” Symptoms are often located on one side of the plant, which can be diagnostic for this vascular wilt disease (Figure 3). As the fungus grows and spreads within the plant from year to year, symptoms appear in more of the canopy. Symptoms are usually most obvious in mid to late summer or fall--frequently after stressful periods of hot, dry weather. In some cases, infected plants suddenly die the season following initial symptoms.

Figure 2. Verticillium-infected Japanese maple leaves with marginal scorch symptoms.

Figure 3. Maple with a portion of the canopy exhibiting symptoms of premature fall coloration.

Plants with chronic infections usually show general decline, as exhibited by sparse canopies consisting of undersized, off-colored leaves, poor growth and vigor, and branch dieback. Infected plants can occasionally produce heavy crops of seeds or samaras. Plant death can be slow or sudden, depending upon the extent of infection and general plant health.

Another diagnostic characteristic of Verticillium wilt is distinctive discoloration or streaking in the sapwood. The color of the discoloration varies by host. For example, it is dark olive-green in maple (Figure 4), chocolate brown in redbud, and brown in elm. Streaking can be random in infected wood--it is not reliably present in small-diameter branches or twigs. However, discoloration is more consistent near the bases of larger, symptomatic branches. Since many other fungi can cause similar discolorations of sapwood, positive diagnosis of Verticillium wilt requires culturing sapwood tissue in the laboratory.

Figure 4. Diagnostic vascular discoloration in sapwood of maple infected with Verticillium wilt.

Verticillium dahliae is soilborne and persists for indefinite periods of time in the soil as resting structures called microsclerotia. Germination and growth of these structures is stimulated by exudates from a host plant or from decaying organic matter. The fungus enters the roots and the water transport system (xylem) of the plant. It then grows, sporulates, and moves systemically throughout the plant. Spores (conidia) are ovoid and are borne on specialized hyphae (phialides) in a whorl around a conidiophore. Verticillium is named for this verticillate or whorled arrangement of the phialides on the conidiophore (Figure 5). The presence of the fungus in the xylem restricts movement of water and nutrients by its physical presence as well as through production of enzymes and toxins. As the fungus grows in the xylem, the plant responds in both physical and biochemical ways to contain or compartmentalize the fungus. This results in plugging and gumming of water-conducting vessels, which further restricts water in the host.

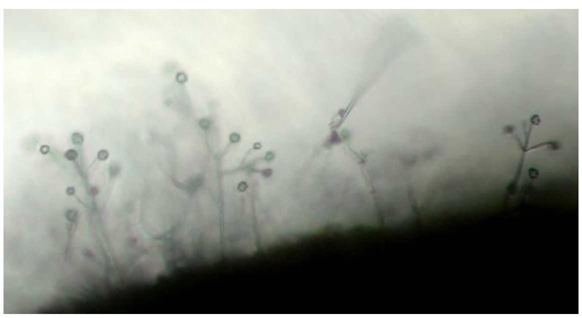

Figure 5. Verticillate spore-bearing structures on conidiophores.

This ongoing interaction between the host and the fungus can help to explain reports of symptom "remission" in some infected plants. Symptoms appear to stop and start for a year or so, although in most cases they reappear and encompass more of the plant canopy. This can be understood as an external expression of what is happening inside the infected plant--symptoms disappear after the plant has successfully compartmentalized the fungus to keep it from spreading. Symptoms reappear when the fungus breaks through the compartmentalization barriers and begins to grow and move again in the host.

Verticillium wilt occurs on a wide range of woody and herbaceous hosts. However, to date, all gymnosperms and monocots appear to be resistant or immune to this disease. A fact sheet "Verticillium Wilt of Vegetables and Herbaceous Ornamentals" has more information on the effects of the disease on nonwoody hosts.

MANAGEMENT STRATEGIES:

Managing Verticillium wilt is most successful using a multifaceted strategy. There are no satisfactory controls for this disease once plants are infected.

- Fungicides are not effective for control.
- For plants that exhibit mild symptoms, it can help to maintain vigor by following sound cultural practices. These include pruning symptomatic branches, watering during periods of drought, and fertilizing (based on a soil test). Mulching is also helpful since it helps maintain soil moisture, moderate soil temperatures, and minimize chances for mechanical injuries. Although infected plants cannot be cured, these practices can sometimes delay the progression of disease for several years.
- *Verticillium* fungi can survive for many years as microsclerotia in the soil. Therefore, it is necessary to avoid planting susceptible species in the areas known to be infested. In such cases, gymnosperms and resistant or immune species should be planted (Table 1).
- Since microsclerotia can be present in soil or debris, it is important to avoid moving soil or debris from areas of known infection.

- As a precaution against spread, all tools should be disinfested between cuts with a 10% solution of household bleach, 70% alcohol, or one of the commercial products such as Physan 20.
- Several studies have demonstrated that microsclerotia can be found in fresh wood chips from infected trees. Although the studies are inconclusive, it is probably best to avoid using fresh chips to mulch susceptible hosts. It is suggested that chips be composted for at least one year prior to use.

Table 1. Resistance of Selected Woody Ornamentals to Verticillium Wilt

Resistant or Immune	Susceptible
Apple *(Malus)*	Ash *(Fraxinus)*
Arborvitae *(Thuja)*	Azalea *(Rhododendron)*
Beech *(Fagus)*	Barberry *(Berberis)*
Birch *(Betula)*	Black Locust *(Robinia)*
Boxwood *(Buxus)*	Box Elder *(Acer negundo)*
Butternut *(Juglans)*	Boxwood *(Buxus)*
Crabapple *(Malus)*	Catalpa *(Catalpa)*
Dogwood *(Cornus)**	Cherry, other stone fruits *(Prunus)*
Fir *(Abies)*	Coffee tree, Kentucky *(Gymnocladus)*
Firethorn *(Pyracantha)*	Currant *(Ribes)*
Gingko *(Gingko)*	Dogwood *(Cornus)**
Hackberry *(Celtis)*	Elm *(Ulmus)*
Hawthorn *(Crataegus)*	Honeysuckle *(Lonicera)*
Hickory *(Carya)*	Lilac *(Syringa)*
Holly *(Ilex)*	Linden *(Tilia)**
Honey Locust *(Gleditsia)*	Magnolia *(Magnolia)*
Hornbeam *(Carpinus)*	Maple *(Acer)*
Juniper *(Juniperus)*	Redbud *(Cercis)*
Katsura tree *(Cercidiphyllum)*	Rose *(Rosa)*
Larch *(Larix)*	Russian Olive *(Elaeagnus)*
Linden *(Tilia)**	Serviceberry *(Amelanchier)**
Mountain Ash *(Sorbus)*	Smoke tree *(Cotinus)*
Mulberry *(Morus)*	Spirea *(Spirea)*
Oak *(Quercus)*	Sumac *(Rhus)*
Pear *(Pyrus)*	Viburnum *(Viburnum)*
Pine *(Pinus)*	Weigela *(Weigela)*
Poplar *(Populus)*	Yellowwood *(Cladratis)*
Serviceberry *(Amelanchier)**	
Spruce *(Picea)*	
Sweet Gum *(Liquidambar)*	
Sycamore *(Platanus)*	
Walnut *(Juglans)*	
Willow *(Salix)*	
Yew *(Taxus)*	

* The resistance or susceptibility of these plants will depend upon the cultivar of the tree and the strain of *Verticillium* present in the soil.

May 2008

Dr. Sharon M. Douglas
Department of Plant Pathology and Ecology
The Connecticut Agricultural Experiment Station
123 Huntington Street, P. O. Box 1106
New Haven, CT 06504

Phone: (203) 974-8601
Fax: (203) 974-8502
Email: Sharon.Douglas@po.state.ct.us

WINTER INJURY AND DRYING OF RHODODENDRON

Rhododendrons throughout Connecticut often exhibit symptoms of winter injury and drying. Symptoms are present on shrubs of all ages and on those growing in both wind-swept and sheltered locations. This type of injury is a result of many environmental factors which often have little in common but that they occur during the winter. The causal factors are very diverse and include sudden temperature fluctuations, excessive or late season fertilization, lack of snow cover, drying winds, and late spring frosts. The most common type of winter injury on rhododendron is excessive drying. This results from factors which create a water deficit in the shrub. This type of injury occurs when water evaporates from leaves on windy or on warm sunny days during the winter or early spring. Drying occurs because this water is not replaced since the roots cannot take up enough water from cold or frozen soil.

Winter injury is important in and of itself but it also predisposes the shrubs and renders them more vulnerable to secondary or opportunistic pests. Another important characteristic of winter injury is that quite often, the symptoms are not evident until sometime **after** the injury has occurred. Symptoms may appear in early spring when growth is just beginning or they may not appear until early-summer or even later in the season. This can make diagnosis difficult.

SYMPTOMS:

Symptoms of winter injury and drying can be varied but are usually characterized by tip or marginal browning of leaves, dieback of tips and branches, desiccation of growing tips or twigs, and longitudinal rolling of leaves along the mid-vein. Symptoms can develop on one or two individual branches or on the entire shrub. This year, poor root health contributed to more extensive and widespread damage than usual on many rhododendrons throughout Connecticut. Particularly hard hit were recently transplanted shrubs which lacked well-developed or established root systems and established shrubs of all sizes and ages which had root systems that were predisposed and damaged by excess water or drought.

MANAGEMENT STRATEGIES:

We obviously can't control the weather but there are steps that we can take that are aimed at minimizing the effects of winter injury. These include: 1) select the appropriate site for planting and maintain optimum growth by using proper growing practices; 2) have sufficient moisture in the root zone before the soil freezes- this can be accomplished by giving the shrubs a deep watering before the ground freezes in the fall; mulching also helps to increase moisture retention in the winter; 3) avoid late summer and early fall fertilization- this stimulates and encourages growth late in the season which may not harden-off properly for the winter; 4) prune and remove any dead twigs or branches which can serve as sites for secondary invaders or opportunistic pests, and 5) provide physical protection from water loss and drying winds- this is especially important for new transplants or plants in exposed locations; burlap wraps and sprays of anti-transpirants or anti-desiccants can be helpful.

November 2003 (revised)

Dr. Sharon M. Douglas
Department of Plant Pathology and Ecology
The Connecticut Agricultural Experiment Station
123 Huntington Street, P. O. Box 1106
New Haven, CT 06504

Phone: (203) 974-8601
Fax: (203) 974-8502
Email: Sharon.Douglas@ct.gov
Website: www.ct.gov/caes

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WINTER INJURY ON WOODY ORNAMENTALS

Weather conditions during the past few winters in Connecticut have been conducive for injury to woody ornamentals. The impact of these conditions is often evident in ornamental plantings in the landscape as well as in woodlands and natural areas throughout the state (Figure 1). The factors that contribute to winter injury are diverse and results often do not appear on woody ornamentals until the following spring and summer. In addition, the extent and severity of the injuries that develop are often more extreme on plants weakened from drought stress, transplant, or from other environmental and site-related stresses.

Figure 1. Mature rhododendron with symptoms of winter injury.

CAUSAL FACTORS:

Winter injury is associated with many environmental factors that have little in common other than they occur during the winter. Examples of these diverse factors include dramatic temperature fluctuations, multiple freeze-thaw cycles, lack of snow cover, unusually warm mid-winter temperatures, extended periods of extreme or abnormally cold temperatures, cool summers followed by warm autumns and sudden drops in temperature, and drying winds.

An example to illustrate how winter injury can occur involves the process of how woody plants prepare for cold temperatures and enter winter dormancy. This process is gradual—as day lengths shorten and temperatures drop, woody plants gradually acclimate to winter temperatures. In this process, all freezable water is removed from living plant cells and it crystallizes between the cells where it will not damage tissues. The only water that remains in the cells is not freezable, so it will not damage the cells. Under normal fall conditions (i.e., when there is a consistent and gradual drop in temperature), cold acclimation is usually complete before freezing weather begins. When this occurs, freezing temperatures are seldom harmful to most woody ornamentals. However, if a woody plant is not exposed to conditions that favor cold acclimation or if late-season growth is still active, those plants are unable to withstand freezing conditions and are injured. Damage can occur in the sapwood, cambium, or phloem or can be confined to the immature, succulent shoots.

In many cases, the damage is not evident until growth begins in the following spring.

Winter injury is important in of itself, but it also predisposes and weakens plants--this makes them more vulnerable to secondary or opportunistic pests. Among these secondary problems are unusually high incidences of branch and twig diebacks such as those caused by *Botryosphaeria* spp. and *Phomopsis* spp., fungi that are normally not considered aggressive pathogens.

As previously mentioned, the symptoms of winter injury are often not evident until a considerable time after the injury has occurred. This can make accurate diagnosis very difficult. On many needled and broadleaved evergreens such as arborvitae and rhododendron, respectively, the symptoms of winter injury may not appear during the winter, but may begin to appear as the spring unfolds. Symptoms may continue to worsen as the plants begin to grow—this can often result in confusion about the actual cause of the damage. For example, when the sapwood of a lilac is damaged by freezing (Figure 2), the symptoms may not be evident until the spring or early summer following the time when the injury initially occurred. Symptoms develop on branches that had "leafed-out" looking apparently normal, which then suddenly collapse and die for no obvious reason. However, the symptoms can be attributed to damage sustained by the sapwood during the previous winter, which cannot provide the amount of water needed by developing leaves and flowers.

Winter injury can occur on a wide range of plants. However, it is often particularly problematic on evergreens in the landscape. These include broadleaved evergreens such as rhododendron, mountain laurel, and holly and needled evergreens such as hemlock, arborvitae, chamaecyparis, pine, and juniper. Deciduous trees and shrubs such as flowering cherry and almond, maple, and dogwood are also damaged by winter injury, as are ground covers such as ivy and pachysandra.

Figure 2. Freeze damage to the sapwood of lilac. Note brown discoloration (arrow).

SYMPTOMS:

Symptoms of winter injury are variable and depend upon the type of plant, its general vigor, and the extent of the damage. Woody plants that are damaged by winter injury will often show tip and branch dieback, foliar browning, sun-scalding, and bark splitting. One common type of winter injury is excessive drying. This is quite common on evergreens and results from factors that create a water deficit in a plant. This type of injury occurs when water evaporates from leaves or needles on windy or warm, sunny days during the winter or early spring. Drying occurs because this water is not replaced since the roots cannot take up enough water from cold or frozen soil.

On broadleaved evergreens such as leucothoe, rhododendron, and mountain laurel, a marginal or tip browning and longitudinal rolling along the mid-vein characterize the most familiar leaf symptom. In some cases, entire branches or shrubs can be affected (Figures 3, 4, 5, and 6).

Figure 3. Leucothoe with symptoms of winter injury.

Figure 4. Close-up of leucothoe leaves with tip necrosis.

Needled evergreens exhibit a slightly different symptom, with browning of the tips or center portions of needles, chlorotic flecking, needle drop, and tip and twig dieback (Figures 7, 8, and 9). In extreme cases, an entire shrub or tree may turn brown or appear off-colored (Figure 10).

Figure 5. Close-up of brown, rolled rhododendron leaves affected by winter injury.

Figure 6. Japanese holly with brown, desiccated leaves showing symptoms of winter injury.

Figure 7. Chamaecyparis with winter injury at branch tips.

Figure 8. Arborvitae with desiccated needles at tips.

Figure 9. Spruce showing browning and desiccation of needles on the last flush of growth.

Figure 10. Recently planted balsam firs with needle browning and drop due to winter injury.

On deciduous trees and shrubs, bark may be injured or split by cold weather. Cracks and dead areas can appear in the bark and the bark begins to peel away from the trunk as the tree grows in spring and summer. This type of damage is common on many of the thin-barked species such as crabapples, cherries, and maples (Figure 11). Frost cracks during dormancy result from the expansion and shrinkage of bark and wood, which causes internal mechanical stress and cracking and splitting of wood, and slipping of bark at the cambium layer.

Figure 11. Crack (arrow) in bark of crabapple associated with winter injury.

Extremely cold winter temperatures can also result in damage to flower and leaf buds (Figures 12 and 13). Buds can also be damaged by periods of unusually warm winter temperatures, which trigger them to begin to break dormancy. When the normal temperatures return, these tender buds are injured. As a consequence of both types of injury, deciduous trees and shrubs may not flower or may fail to leaf out properly in the spring. Cold temperatures occasionally cause sub-lethal or lethal damage to sapwood and cambial tissues. This type of injury usually does not appear early in the season but causes new branches to suddenly wilt and begin to die back by early to mid-summer. Injured tissues apparently cannot keep up with the water demands of actively growing plants and the plants collapse.

Figure 12. Azalea with dead twigs and flowers associated with winter injury.

Figure 13. Close-up of dead flower buds (arrows) on azalea with winter injury. Note that the leaves around the buds are healthy.

MANAGEMENT AND REMEDIATION STRATEGIES:

Although the weather cannot be manipulated and there are no "cures" for winter injury once the damage is done, there are steps that can help to minimize the effects of winter injury.

- Select the appropriate site for planting and use sound cultural practices to maintain vigor.
- Select native plants or match plants to the site. For example, avoid planting broadleaved evergreens in open, windy locations where they will be subjected to drying winter winds.
- Maintain adequate soil moisture in the root zone before the soil freezes. This can be accomplished by giving the plants (esp. broad and needled evergreens) a deep watering before the ground freezes in the fall. Mulching can also be beneficial since it helps to increase moisture retention during the winter.
- Avoid late summer and early fall fertilization. This can stimulate and encourage plant growth late in the season, which may not acclimate properly for cold winter temperatures.
- Prune and remove any dead twigs or branches since they can serve as sites for secondary invaders or opportunistic pests.
- Provide physical protection from water loss and drying winds. This is especially important for new transplants or plants in exposed locations. Protection can be provided by installing burlap wraps and by using applications of anti-transpirants to evergreens in order to minimize water loss from needles or leaves.

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Dr. Sharon M. Douglas
Department of Plant Pathology and Ecology
The Connecticut Agricultural Experiment Station
123 Huntington Street, P. O. Box 1106
New Haven, CT 06504

Phone: (203) 974-8601
Fax: (203) 974-8502
Email: Sharon.Douglas@po.state.ct.us

YELLOWING, DIEBACK, AND DEATH OF NEEDLED EVERGREENS

Every year, many needled evergreens develop symptoms of needle yellowing and browning, tip dieback and needle drop, poor vigor, and even death. Pine, yew, hemlock, and juniper are among those commonly affected. Although these symptoms can sometimes be attributed to fungal pathogens or other disease agents, in *many* cases the symptoms are associated with environmental factors. These factors act singly or in combination and result in plant stress and damage. The most common causes are wet soil, drought or dry soil, winter damage, and low-light or shading.

WET SOIL:

Roots in flooded or water-logged soils are damaged and die from oxygen deficiency. Feeder roots are particularly sensitive and are frequently the first ones damaged. When roots are damaged, they are unable to provide water to the top of the plant. Damage can be sudden or gradual, depending upon the plant and the flooding conditions. This can occur on plants in obviously wet sites and on those in marginal sites or soils such as along city streets or in areas where high clay content in the soil impedes drainage. Most trees cannot grow in water-logged soils for very long and can die if flooded for only a few days during the growing season. Visible symptoms are **often** not evident until considerably after the damage has occurred, especially when the root damage is gradual. Seedlings and new transplants are more sensitive than established plants and gymnosperms (needled evergreens) are generally considered more sensitive than angiosperms. Top symptoms may not develop until water demands increase during the hot summer months. Other evergreens appear to lose vigor and slowly decline over a period of years. This can occur on trees that have been otherwise "healthy" for 10-15 years but are growing in poor sites or heavy soils. Dormant plants generally appear to tolerate flooding longer than those in active growth. In addition to direct root damage, trees in flooded soils are predisposed to secondary root rot pathogens and other opportunistic pests.

Strategies for minimizing wet soil problems include: 1) selection of an appropriate site and proper planting practices; 2) cultural practices that maintain plant vigor and stimulate growth; 3) selection of appropriate species for soil and site conditions: water-tolerant (larch) vs. water-intolerant (spruces, hemlocks, yews); and 4) pruning dead or dying tissues to minimize secondary invaders.

DROUGHT OR DRY SOIL:

Drought or dry soil conditions resulting in feeder root damage and death contribute to the development of water deficits in plants. Symptoms are manifest in different ways but are often not evident until some time after the event has occurred- **even as much as a year later!** Effects are particularly severe on seedlings or new transplants because their roots occupy the uppermost layers of soil where the most rapid drying occurs and are compounded by the loss of feeder roots during the transplant process. It often takes woody transplants two years to become completely established in a new site. Established trees are also affected, especially in marginal sites such as those in pockets of soil on ledges or in sandy soils or those that had been improperly planted. Native plants are usually adapted to regional and seasonal fluctuations in the amount of precipitation and only unusually severe drought causes problems. In addition to direct root damage, drought predisposes the plant to secondary invaders.

Drought stress can be minimize by: 1) watering in periods of low soil moisture: trees and shrubs require approximately one inch of water per week, best if applied at one time as a slow, deep soaking; 2) selecting an appropriate site and following good planting practices; 3) selecting native plants or matching plant species to site conditions: drought-sensitive (arbor vitae) vs drought-tolerant (some junipers); 4) mulching to maintain soil moisture; and 5) pruning any dead or weakened tissues to avoid secondary problems.

WINTER INJURY:

Winter injury or drying results from factors which contribute to a water deficit in a plant. Injury commonly occurs on plants growing in wind-swept or in sheltered locations. Water evaporates from the needles on windy or warm sunny days during winter or early spring. This water is not replaced since the roots are not able to obtain sufficient water from cold soil nor can they absorb any water from frozen soil. Damage often appears on one side or on one branch, usually the side facing prevailing winds and one-third to one-half of each needle is often browned. Visible symptoms often do not appear until the following spring or summer. Winter drying also weakens a plant making it more susceptible to opportunistic pests.

While there is no cure for this disorder, steps to help minimize the effects of winter injury include: 1) select an appropriate site for planting and maintain plant vigor by good cultural practices; 2) deep water plants before the ground freezes in the fall and mulch around the base of the plant to provide and maintain sufficient moisture in the root zone; 3) fertilize at the proper time and rate- avoid late summer and early fall fertilization; 4) prune dead or weakened branches prone to secondary problems; and 5) construct physical barriers to minimize drying winds.

LOW-LIGHT NEEDLE DROP:

Shading or low-light conditions may result in a slow decline of some evergreens, especially established, somewhat overgrown arborvitae, yew, hemlock, and juniper. Initial symptoms appear in the center of the plant where light is most limited and needles yellow and drop. Branch dieback occurs and the plant loses vigor. This problem can be minimize by following a regular pruning and general care program throughout the life of the plant.

November 2003 (revised)

The Connecticut Agricultural Experiment Station
123 Huntington Street, P. O. Box 1106
New Haven, CT 06504
(203)974-8601
www.ct.gov/caes/pdio

PLANT DISEASE INFORMATION OFFICE
SAMPLE SUBMISSION GUIDELINES

The Plant Disease Information Office (PDIO) at The Connecticut Agricultural Experiment Station (CAES) is a full-service plant disease diagnostic laboratory that assists all Connecticut stakeholders, including homeowners and professionals.

For the fast, accurate, professional service that you need and demand, please keep a few things in mind when submitting samples. Please use the PDIO Sample Submission Form and provide as much information on the form as possible. For faster response, please include your phone number and email address and indicate how you would prefer to receive the results. Samples should be submitted to:

Mailing Address:
The Connecticut Agricultural Experiment Station
Plant Disease Information Office
P. O. Box 1106
New Haven, CT 06504

Physical Address (for UPS, FedEx, etc.):
The Connecticut Agricultural Experiment Station
Plant Disease Information Office
123 Huntington Street
New Haven, CT 06511

Collecting Plant Specimens for Disease Diagnosis/or Plant Identification

Sample must be fresh and in good condition. It is helpful if the sample is taken from an area that has early symptoms of the problem. Damaged or completely dead specimens are often unidentifiable and requests for additional samples can cause delays. Collect samples prior to any pesticide applications when possible. Once pesticides have been applied, it may be difficult to obtain an accurate diagnosis.

1. Leaves, Branches or Fleshy Parts of Woody Ornamentals: send specimens representing early and moderate stages of the symptoms you are observing. For leaves, collect at least 10 leaves and press them flat between heavy paper or cardboard and place in plastic bags. For twig or branch cankers, collect samples that include healthy portions from above and below the diseased area. Wrap fleshy parts in dry paper and place in a plastic bag.
2. Herbaceous Plants with Decline or Wilt: for general decline or dying of plants, send whole plants showing early symptoms. Dig plants carefully to keep the roots and adjacent soil intact. Send several plants. Wrap the roots in a plastic bag and secure at the base of the stem so soil does not contaminate the aboveground portions. Place the entire plant, with wrapped roots, in another plastic bag.
3. Trees with Symptoms of Wilt: collect several branches approximately ½ to 1 inch in diameter from portions of the canopy that are actively wilting or yellowing, but not totally dead. Branches can be cut into pieces and put in a plastic bag.
4. Turf: sample plugs should be at least 4-6 square inches and include the transition area between the diseased and healthy portion of grass. The sample should also be cut deep enough so as to include the root system. Wrap the sample in newspaper and place it in a plastic bag.
5. Plant and Weed Identification: include a 6-10 inch sample of the terminal (tip) portion of the stem/shoot with side buds, leaves, flowers, and fruit in identifiable condition. Flowers (and fruit) are often necessary for accurate identification. Whole, uncut fruit should be wrapped in paper, bagged, and placed in a crush-proof container.

Packaging and Mailing Samples

Rapid delivery may be critical. DO NOT add water in plastic bags.
1. Package the sample plastic bags and the sample submission form in a sturdy, crush-proof box or mailer.
2. If submitting more than one sample, please label the outside of each bag clearly with a permanent marker.
3. Add packing materials such as newspaper to prevent specimen damage during shipment.
4. Try to mail the sample as quickly as possible. If the sample cannot be mailed immediately after it is taken, keep it refrigerated or out of direct sunlight and hot conditions.
5. Mail packages to arrive on weekdays. DO NOT mail late in the week to ensure that packages won't sit in the post office over the weekend.

Please feel free to contact Dr. Yonghao Li or Ms. Lindsay Patrick by telephone (203-974-8601), or email Yonghao.Li@ct.gov or Lindsay.Patrick@ct.gov with any questions. Providing answers to your questions prior to sample submission may enable us to get you the answers you need more quickly. When possible, please submit multiple digital images of affected plants including the surrounding area and close-up images via email, which allows a more timely response and help us to suggest the most an appropriate physical sample to submit for diagnosis. The PDIO also provides an informational website that is located at the following URL address: http://www.ct.gov/caes/pdio.

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New Haven, CT 06504
(203)974-8601
www.ct.gov/caes/pdio

PLANT DISEASE INFORMATION OFFICE
SAMPLE SUBMISSION FORM

Name: ____________________
Business: ____________________
Street Address: ____________________
City, State, Zip: ____________________
Phone: ____________________
Cell: ____________________
Email: ____________________

Homeowner ☐ Grower ☐ Landscaper/Arborist ☐ Other ☐

FOR OFFICE USE ONLY	
Sample Number	
Date Received	
Date Reported	
Diagnosis	
Diagnosed by	
Via	

Sample For: Disease Diagnosis ☐ Plant Identification ☐ Weed Identification ☐

Plant: ____________________ ____________________
Common and/or Scientific Name Cultivar or Variety

DESCRIPTION OF PROBLEM

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Symptoms	Age of Plant or Planting	Distribution of Problem	Nature of Planting	Additional Information	
wilting ☐	1-6 months ☐	entire planting ☐	yard ☐	When did problem appear?	
blight ☐	6 months-1 year ☐	random ☐	field ☐		
leaf spot ☐	1-3 years ☐	edge of planting ☐	nursery ☐		
galls ☐	3-5 years ☐	wet areas ☐	greenhouse ☐	Did problem occur gradually?	
rot ☐	more than 5 years ☐	dry areas ☐	orchard ☐		
dieback ☐	**Affected Parts**	high areas ☐	forest ☐		
streak ☐	stems ☐	low areas ☐	indoor ☐	Number of plants affected	
yellowing ☐	leaves/needles ☐	sunny areas ☐	**Soil Type**		
marginal burn ☐	branches/twigs ☐	shaded areas ☐	sandy ☐		
mosaic ☐	fruits ☐	**Drainage**	clay ☐		
leaf drop ☐	roots/bulb ☐	good ☐	loamy ☐	Irrigation type and frequency?	
Other:	flowers ☐	fair ☐	potting mix ☐		
	entire plant ☐	poor ☐	mulch ☐		
Use of Pesticides/Fertilizers (rate and date/s of application)					

NOTES

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