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2005 UPDATE ON THE EASTERN RED CEDAR PROBLEM

Last year, in late March and early April 2004, The Plant Disease Information Office received an unusual number of phone inquiries and samples of ailing Eastern red cedar, *Juniperus virginiana,* from throughout the state. The calls and samples continued into May. This year, we received more calls and samples from symptomatic trees, some of which showed symptoms last year and continued to decline and some of which were on trees exhibiting symptoms for the first time. During 2004, similar symptoms were reported on red cedars from northern New Jersey into southern New York (Long Island) and southern Massachusetts. No symptoms were reported from more northern eastern states such as New Hampshire, Vermont, or Maine.

SYMPTOMATOLOGY AND POSSIBLE CAUSES

Although this native species is usually considered relatively trouble-free in Connecticut, for the past two years, dramatic and conspicuous damage was visible on trees in all age and size classes, care regimes, and locations, including natural stands and managed landscapes. Severely affected trees appeared distinctly off-color from a distance. Upon close inspection, a range of symptoms could be observed, which included needle browning and drop, primarily of older, inner needles, tip and twig dieback, and branch death. In extreme cases, entire trees turned brown. These symptoms were not distinctive or diagnostic. We have had reports of trees without a history of symptoms or problems exhibiting extensive symptoms in both spring 2004 and 2005. Trees in compromised sites (e.g., exposed to road salt, increasing levels of shade) also exhibited a range of symptoms. In some cases, new growth was observed at the bases of small, dead twigs. This suggested that cambial tissues were still viable on some of the larger-diameter wood, despite extensive needle browning, drying, and premature drop.

After two years of examination of samples, no pathogens, insects, or mites have been directly associated with these symptoms. However, efforts to further characterize and identify the cause(s) are still ongoing. The occurrence of symptoms in a localized area of New England during 2004 provides further evidence for an environmental phenomenon or series of events. One possible scenario to explain the development of the symptoms includes damage from weather conditions of this past winter that occurred on trees previously stressed by several years of dry conditions and the extremely wet conditions of the 2003 and 2004 seasons. Although 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 resulted in greater than usual damage. Both winters of 2004 and 2005 were quite severe. Winter injury results from many environmental factors, which 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 (http://www.caes.state.ct.us/FactSheetFiles/IndexHeadingFiles/FSlisting.htm) or upon request.

The damage to the red cedars that we've observed for the past two years is significant but also serves to predispose and weaken the 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. Consequently, it might be wise to check for infestations next season. Infestations of this longhorn beetle can be recognized as serpentine tunnels on the main trunk or on larger-diameter branches.

Last year, 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 that 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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ANTHRACNOSE DISEASES OF TREES

Anthracnose diseases occur on important shade and tree species throughout Connecticut every year although the severity and distribution of these problems vary with each season, site, and species. These diseases are common on ash (*Fraxinus*), maple (*Acer*), oak (*Quercus*), and sycamore (*Platanus*). Anthracnose is most noticeable on trees in the landscape but disease also occurs on trees growing in natural woodlots and forests. 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., drought, excess water, winter injury).

The term "anthracnose" refers to diseases caused by fungi that produce conidia in structures called acervuli (Deuteromycotina, Coleomycetes). These fungi can infect leaves, flowers, fruit, and stem tissues. Infections are usually initiated in spring when new growth is emerging but can occur 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 and dieback of twigs and branches. Symptoms also vary with the individual host and the causal fungus. Anthracnose symptoms are apparent from late spring to early summer but additional cycles 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 most apparent after several successive years of disease. Most trees that have dropped leaves prematurely usually produce new shoots and leaves by midsummer. Trees that are otherwise healthy can fortunately withstand several years of defoliation without long-term implications.

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. When infections are moderate, only portions of each leaflet will be affected. 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 midsummer.

MAPLE ANTHRACNOSE:
Causal Agents: *Discula* sp*., Kabatiella apocrypta*
Hosts: *Acer* (Japanese, Norway, sycamore, red or swamp, silver, and sugar maple).
Symptoms: 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 areas at leaf margins. Although symptoms vary with the type of maple, symptoms that are common to most maples are the large, irregular dead areas on the leaves. These are often V-shaped or delineated or defined by the veins. These areas can be tan and paper-thin. When infection is severe, the fungus enters the petiole 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. Samaras can also develop necrotic or dead spots and drop. Significant leaf drop can occur in late spring but trees usually refoliate by midsummer.

SYCAMORE ANTHRACNOSE:
Causal Agents: *Apiognomonia veneta (Discula platani)*
Hosts: *Platanus* (sycamore, London plane)
Symptoms: Sycamore anthracnose often occurs in three phases, each of that can result in different types of symptoms. The three phases are twig and branch cankers, shoot blight, and leaf blight. Weather patterns usually influence the severity of each phase. In the first phase, the presence of the fungus in twigs and buds over the winter 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. 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. Leaves are most susceptible during the first few weeks of growth. Symptoms include foliar lesions that extend along the veins and develop into large, brown areas on the leaves. Significant leaf drop can occur in early summer although by midsummer most trees will have refoliated with a canopy of healthy leaves.

OAK ANTHRACNOSE:
Causal Agents: *Apiognomonia quercina (Discula quercina)*
Hosts: *Quercus* (white, black, pin, burr, 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. When the spots are numerous, they coalesce and give the leaves a blighted appearance. Heavily infected leaves become distorted and often drop prematurely by early summer. However, trees usually refoliate by midsummer.

MANAGEMENT STRATEGIES FOR ANTHRACNOSE DISEASES:

Control of anthracnose diseases 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.

- 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 spores available to infect emerging shoots and leaves in spring and during the growing season.
- Tree vigor should also be maintained by following sound cultural practices such as proper watering, fertilizing, 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 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, copper sulphate pentahydrate, and mancozeb. 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 budbreak. 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.

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ASH LEAF RUST

SYMPTOMS AND DISEASE CYCLE:

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 kinds of host plants to complete its life cycle. These are several species of ash (*Fraxinus* spp.) and several cord or marsh grasses (*Spartina* spp.). This disease appears to run in cycles of approximately 5-7 years.

Ash leaf rust is most severe along the New England coast where the fungus reproduces and overwinters on grasses in salt marshes. In spring, clouds of rust spores move inland from the marshes. Severe rust often develops on ash after periods of foggy weather with onshore airflow. In epidemic years, ash leaf rust has been noticed as far as 48 km inland. Infection of ash occurs on leaves, petioles, and green twigs during May and June. Leaves are conspicuously distorted and diseased tissues swell, often causing sharp bends in the petioles and elliptic, wartlike galls on green twigs. Spots on leaves may enlarge to several millimeters in diameter. 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 in minute, cup-like structures. These spores are incapable of reinfecting ash trees, but reinfect the marsh or cord grass hosts in July and August. The fungus multiplies and builds up on these grass hosts in late-summer, often reaching epidemic levels since rust infections on these hosts are scarcely noticed. 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.

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. Infected trees should be fertilized and watered during periods of drought to promote vigor and growth.

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BLACK KNOT OF PLUM AND CHERRY

SYMPTOMATOLOGY AND DISEASE CYCLE:

Black knot, caused by the fungus *Apiosporina morbosa*, is quite common on many flowering *Prunus* species in the landscape as well as on wild plums and cherries in woodlots. It is also a very destructive disease of plum and prune trees in orchards. 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 growth beyond the knots. Trees can be severely weakened, disfigured, and, in extreme cases, even killed as a result of infection.

Symptoms are easily recognized as hard, black, elongate swellings or galls on twigs, branches, and trunks of trees. While knots are most outstanding on dormant trees, newly formed knots are greenish and soft but become hard and black with age. The fungus overwinters on infected twigs and produces spores in spring. New shoots are susceptible and can be infected soon after budbreak and throughout the period of active shoot elongation. However, most infections are thought to 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 these 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:

Control is best achieved using a combination of culture, pruning and sanitation, properly timed fungicide sprays, and resistant varieties. **Pruning and sanitation are essential** to any control program since 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 cuts made at least 6-8” below any visible swellings or knots.

Cultural methods involve removing and/or pruning of any wild plum or cherry trees found in woodlots within 600 ft. of the landscape tree in question. These wild trees are highly susceptible to black knot and can be important sources of inoculum.

Resistance is an option for control since edible plum varieties differ in their susceptibility to black knot. The cultivars Stanley, Damson, Bluefree, and Shropshire are considered 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 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. The fungicides chlorothalonil and mancozeb + copper hydroxide are registered for use on many ornamental *Prunus* species. Applications are usually made when the tree is dormant (just before budbreak) and continued until flowers have fallen (petal-fall). 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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BRIEF SYNOPSIS OF TREE DISEASES BY CATEGORY

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.

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

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;
- Sgnificant defoliation can occur;
- Most serious during wet, cool springs.

Examples:
Anthracnoses (of many hosts)
Dogwood Anthracnose

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

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)

Rusts-
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
Sphaeropsis Tip 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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CANAVIRGELLA NEEDLECAST OF PINE
NEW NEEDLECAST DISEASE FOR CONNECTICUT

In August 1998, The Plant Disease Information Office started to receive an unusual number of phone inquiries and samples of ailing white pines from throughout the state. The symptoms on the trees were distinctly different from those associated with diseases of white pine previously reported in Connecticut. After extensive microscopic examination and search of the literature, the disease was identified as Canavirgella Needlecast. This disease has never been reported for Connecticut although it is thought to be present along the Eastern Seaboard, from North Carolina to Maine. The first report documenting the association of the fungus *Canavirgella banfieldii* with this needlecast disease appeared in 1996.

SYMPTOMATOLOGY AND DISEASE CYCLE:

This needlecast, caused by the fungus *Canavirgella banfieldii,* is a disease of *Pinus strobus* (Eastern white pine) and *Pinus peuce* (Macedonian white pine). Infected trees appear distinctly reddish brown from a distance in late July and early August. Upon close inspection, the symptoms are usually confined to current-season needles. Tips of infected needles first appear yellowish-tan and develop a distinct reddish-brown color by late August. By the following spring, infected needles curl and fade to tan or gray. One of the diagnostic characteristics of the disease is that not all needles within a fascicle are infected. Additionally, individual needles within a fascicle may exhibit differing amounts of symptomatic tissue. When needles are infected with *Canavirgella*, the bases of the symptomatic needles usually remain green and 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 needlecast have frequently been confused with those associated with acute ozone injury and other needlecast diseases. However, with ozone, symptoms usually develop on all of the needles within a fascicle and needles exhibit the same extent of injury.

Infection of succulent, elongating, current-season needles apparently occurs in late June or early July. The spores (ascospores) of the fungus are thought to be released during early stages of needle elongation and during periods of favorable weather. As

with most needlecast pathogens, extended periods with free water on the needles are conducive for infection. 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.

MANAGEMENT STRATEGIES:

As with most needlecasts, control of Canavirgella needlecast can be achieved using a multifaceted approach. This disease can often be effectively controlled by following good sanitary and cultural practices. Tree vigor should be maintained by proper watering, fertilizing, and pruning. Although needlecasts are usually considered to be more aesthetic than life-threatening and are rarely serious enough to warrant chemical control, there are situations where they can be serious and cause permanent damage, disfigurement, or even tree death. Newly transplanted trees or trees weakened by stress are particularly sensitive to repeated premature needle drop. In such cases, chemical control could be beneficial. However, once symptoms are visible on the needles it is too late for chemical applications. Because of the newness of this disease to Connecticut, specific fungicides are not labeled for use. Please contact the Experiment Station for the most current information on control.

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CEDAR-APPLE RUST

SYMPTOMATOLOGY AND DISEASE CYCLE:

Cedar-apple rust, caused by the fungus *Gymnosporangium juniperi-virginianae*, is a distinctive disease that is indigenous and widespread throughout the Northeast in areas where apples, crabapples, and other related members of the Rose family grow in close proximity to *Juniperus* species such as Eastern red cedars and junipers. This fungus requires these two different hosts in order to complete its two-year life cycle.

The symptoms of this rust disease on red cedar and juniper are inconspicuous during the winter and appear as green to greenish-brown, kidney-shaped galls that vary in size from ¼ - 2 inches in diameter. During cool, rainy periods in the spring, distinctive bright orange, gelatinous telial horns (also called "spore horns") up to four inches long protrude from the surface of these galls. Tiny spores are released from these spore-horns and are carried by wind and driving rain to infect the alternate apple and crabapple hosts. As many as 7.5 million spores may be produced in a single gall and these spores have been known to be carried as far as six miles.

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 and develop a characteristic bright yellowish-orange color and are visible on both the upper and lower leaf surfaces. Occasionally, symptoms develop on fruit and twigs. By midsummer, minute "spore cups" called aecia develop at the edge of the lesions on the lower leaf surface. The spores produced in these cups are released from midsummer into autumn and are carried by wind and rain back to the juniper and red cedar hosts where they complete the disease cycle. When these spores land, they germinate and stimulate the formation of galls, a process that takes from 19-22 months for completion.

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 junipers are: *Juniperus chinensis* var. *sargentii*, *J. communis* cv. Aureospica, and *J. virginiana* cv. Tripartita. Resistant apple cultivars include Delicious, Empire, Jonamac, McIntosh, and Paulared. Resistant crabapples include Ellwangerina, Henry Kohankie, Ormiston Roy, and Red Baron.

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 interval, and safety precautions. Among the fungicides registered for use in Connecticut are chlorothalonil, ferbam, mancozeb, triadimefon, triforine, and myclobutanil are registered for use and should be applied as necessary. 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 midsummer-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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COMMON DISEASES OF CRABAPPLE

There are a number of diseases that commonly occur on crabapples in home plantings. Scab, cedar-apple rust, and cedar-hawthorn rust are diseases that are usually encountered every year whereas fire blight is an occasional problem. Many factors contribute to both the occurrence and the severity of these diseases. Some of these include: severity of the infection the previous year, weather at the time of budbreak, cultural practices, and type of crabapple variety planted.

I. CONTROL STRATEGIES:

Crabapple diseases can be effectively controlled through the combined use of culture, sanitation, resistance, and fungicide sprays. This integrated approach to disease control minimizes the reliance upon one type of control over the others and usually results in effective disease control.

A. CULTURE-

Cultural methods include maintaining tree vigor by proper planting, fertilizing, and pruning and by following general practices that help to minimize tree stress.

B. SANITATION-

Sanitation involves pruning and removing affected or dead portions of the tree and removing diseased foliage and fruit, which are often important sources of inoculum for the next season.

C. RESISTANCE-

Resistance involves selection and planting of varieties with genetic resistance to specific diseases. This effectively reduces or eliminates occurrence of the disease in question.

D. FUNGICIDE SPRAYS-

Proper selection, timing, and application of these sprays are important. Thorough coverage of all parts of the tree is necessary and sprays should be applied until run-off. The fungicide label will contain information on plant hosts and diseases, dosage rates, and safety precautions.

II. COMMON DISEASES:

A. SCAB-

Scab, caused by the fungus *Venturia inaequalis*, is the most common and one of the most devastating diseases of crabapple in Connecticut. Defoliation of trees as a result of this disease is not only unsightly, but also reduces the vigor of the tree, making it

more susceptible to environmental stress and other opportunistic pests. Scab is usually most severe in wet weather. The fungus causes circular, olive-black spots on the leaves, fruit, and young fruit stems. As the spots develop, the leaves may turn yellow and drop prematurely. Symptoms typically first appear on the leaves in May or early June. Heavy infections can result in defoliation by June.

The fungus overwinters on dead, fallen leaves and produces spores (primary) in the spring that can infect sepals, young leaves, and young fruit during periods of rain. Infection from these primary spores can take place at any time after growth begins until mid to late June if suitable weather conditions exist. During the summer, a different spore (secondary) is produced by the fungus that is capable of inciting more new infections when splashed onto leaves and fruits by rain.

Scab is most effectively controlled by planting resistant varieties. A partial list of resistant crabapples 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. A good sanitation program in that diseased leaves and fruit are removed from the vicinity of the tree will also help to eliminate sources of inoculum in the spring. Scab can also be controlled with properly selected and timed fungicide sprays. Among the fungicides registered for use in Connecticut are thiophanate methyl, mancozeb, chlorothalonil, chlorothalonil + fenarimol, and copper sulphate pentahydrate. Applications can be made at budbreak and repeated at label intervals until mid-June. More frequent sprays may be necessary in wet weather.

B. CEDAR-APPLE RUST-

Cedar-apple rust, caused by the fungus *Gymnosporangium juniperi-virginianae*, is a problem when crabapple and certain species of juniper and red cedar grow in close proximity. This rust requires two different hosts to complete its life cycle. The fungus causes brilliant yellow-orange spots or lesions on crabapple leaves and occasional lesions on the calyx end of the fruit. On cedar, the fungus produces brown to reddish-brown galls, ¼ -2 inches in diameter. During rainy periods in the spring, distinctive bright orange, gelatinous spore-horns protrude from the surface of these galls. The spores are blown by the wind to crabapple trees where they infect and produce their characteristic lesions.

Removal of unwanted junipers or cedars located in close proximity to the crabapple tree usually reduces the number of spores capable of infecting although this is often not practical. Galls can also be removed from juniper branches during dormancy. However, selection and planting of resistant varieties are the most important and effective methods of control. Examples of rust-resistant varieties are: Ellwangerina, Henry Kohankie, Ormiston Roy, and Red Baron. Where the disease seldom occurs or few leaves are infected, no control is necessary. Where disease is frequent and severe, fungicide sprays can be applied to the rosaceous hosts. Among the fungicides registered for use in Connecticut are chlorothalonil, ferbam, mancozeb, triadimefon,

triforine, and myclobutanil. 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 *Juniperus* hosts is usually not practical since it often requires a season-long spray program.

C. CEDAR-HAWTHORN RUST-

Cedar-hawthorn rust is caused by *Gymnosporangium globosum*, a fungus that is related to the cedar-apple rust fungus. Because these fungi are so closely related, the diseases caused by them are very similar. Cedar-hawthorn rust also requires two different hosts in order to complete its life cycle--these include *Juniperus* species (e.g., Eastern red cedar) as well as many rosaceous species. However, cedar-hawthorn rust has a wider rosaceous host range than cedar-apple rust, which includes apple, crabapple, many hawthorns, pear, quince, and serviceberry. Mountain ash and medlar have also been experimental hosts of this fungus. The disease cycle is essentially the same as previously described for cedar-apple rust. Cedar-hawthorn rust usually infects leaves but can also produce symptoms on fruit and green stems, which results in deformity. Cedar-hawthorn rust can be distinguished from cedar-apple rust by several attributes of the aecia on the undersurface of the leaves of the rosaceous host. For example, the fingerlike projections of the aecia of cedar-hawthorn rust are substantially longer than those of cedar-apple rust. Additionally, cedar-hawthorn rust produces slightly smaller, more flattened galls on the juniper hosts.

Control strategies are essentially the same as for cedar-apple rust. Hawthorns with reported resistance include English hawthorn, Cockspur thorn, yellow-fruited thorn, *Crataegus intricata*, and *C. pruinosa.*

D. FIRE BLIGHT-

Fire blight, caused by the bacterium *Erwinia amylovora*, is the most devastating disease of crabapple. 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. The bacteria survive the winter in old cankers on 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 and they pick it up and carry it to open flower buds where infection occurs. 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.”

The most effective method for control of this disease is to select and plant crabapple varieties that are resistant to fire blight. These include: Adams, Callaway, David, Dolgo, Harvest Gold, Indian Summer, Jewelberry, Liset, Profusion, Red Baron, Selkirk, and Sentinel. Sanitation is also 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. The effects of this disease can also be minimized by maintaining overall tree health by following proper cultural practices that avoid excessive vigor. It is especially important to avoid heavy applications of nitrogen in spring.

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COMMON DISEASES OF MAPLES

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 that 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. 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.
Management: Refer to management strategies for foliar diseases

II. LEAF SPOTS and TAR SPOT:

Causal Agents: Several genera of fungi: leaf spots (e.g., *Phyllosticta*, *Didymosporina*), tar spots (*Rhytisma acerinum* 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. Small, black fruiting bodies may be visible on the upper surface of the spots. These diseases are usually more severe on red, sugar, and silver maple but can occur on Japanese and Norway maple.

- **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. 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*). Significant premature fall coloration and defoliation can occur, especially when infection is heavy (as is often the situation on Norway maple).

Management: Refer to management strategies for foliar diseases

III. POWDERY MILDEW:

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

Symptoms: Leaves develop a somewhat "dirty" appearance due to the presence of a white to grayish, powdery growth on the leaf surface. 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.

Management: Refer to management strategies for foliar diseases

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"). This usually occurs in midsummer, 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. 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.

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 soilborne, it is necessary to avoid planting susceptible species in the area. A list of resistant species can be found 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. 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 can't 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.

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)**
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 *(Cladrastis)*
Serviceberry *(Amelanchier)**	
Spruce *(Picea)*	
Sweetgum *(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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COMMON DISEASES OF ROSE

The rose is often called the "Queen of the Flowers" and is the most popular garden plant in the world. Unfortunately, many roses are also susceptible to a number of diseases that lessen their value in the landscape. In Connecticut, the common diseases of rose include black spot, powdery mildew, downy mildew, Botrytis blight, cankers (brand and common canker), rust, crown gall, mosaic, and winter injury. Each year, the severity and distribution of these problems vary with the weather, the site, and the type of rose.

Many rose diseases can be effectively avoided or minimized through the combined use of culture, sanitation, resistance, biologicals, and pesticide sprays. For example, there is renewed interest in the old garden roses because of their resistance to many diseases and their winter hardiness. By following an integrated approach, reliance upon one type of control over others is reduced and usually results in effective management of disease.

BLACK SPOT

Black spot, caused by the fungus *Diplocarpon rosae*, is one of the most common and persistent diseases of rose in Connecticut. Symptoms on the leaves are recognized as circular, black spots with fringed margins. These spots are often surrounded by yellow halos. Infections can result in extensive yellowing of leaflets or entire leaves. Yellowed leaves drop prematurely, especially on susceptible cultivars. Plants that defoliate by mid-season are weakened, have reduced flower bud set, poor flower quality, and are susceptible to environmental stresses, particularly winter injury. Symptoms can also develop on canes. They appear as purple-red blotches that blacken with age and develop a blistered appearance. Cankers serve as a means for survival of the fungus over the winter and are important sources of inoculum for new infections in spring. The fungus also overwinters in dead, fallen leaves and plant debris. Black spot is usually most severe in wet weather.

One approach to manage black spot is to plant resistant varieties. However, since there are many strains of the fungus, resistance can be variable. It is therefore important to plant varieties known to be resistant to the strains of the fungus that are present in a particular area. Some cultivars with resistance to black spot are David Thompson,

Coronado, Simplicity, Las Vegas, and Cary Grant. Black spot may also be reduced by following a good sanitation program that includes removing infected leaves as soon as they appear during the growing season and raking and removing all fallen leaves and plant debris in the fall. Diseased canes should also be pruned back to healthy wood in spring prior to budbreak. It is helpful to have sufficient space between plants to ensure good air circulation. Avoiding overhead irrigation or watering early in the day are also effective in minimizing conditions favorable for disease development. Plant vigor should also be maintained by following a program of sound cultural care. Fungicide sprays can supplement other options for black spot control. Among the compounds registered in Connecticut are captan, thiophanate methyl, chlorothalonil, fixed copper, triforine, sulfur, potassium bicarbonate, and mancozeb. Consult the label for dosage rates and safety precautions. Applications can be made when new growth appears in the spring and continued as long as conditions are favorable for disease development.

POWDERY MILDEW

Powdery mildew, caused by *Sphaerotheca pannosa* var. *rosae*, is a common disease of rose worldwide and is particularly troublesome for glasshouse roses. This disease is recognized by the white, powdery growth on leaves, shoots, and buds. Early symptoms of disease appear as chlorotic or reddish areas or patches on leaves that eventually develop the characteristic white, powdery appearance. This diagnostic, powdery, white growth is usually found on the upper surfaces of leaves but it can occur on both upper and lower leaf surfaces. When newly emerging shoots are infected when young, shoots can be distorted and twisted. Young leaves may curl upward and may be deformed. Flower buds infected with powdery mildew often fail to open. Powdery mildew can develop under relatively dry conditions in spring or midsummer as long as the air is humid and warm. Unlike other fungi that require free water in order to infect, the powdery mildew fungus does not require moisture on the tissues for infection. This fungus also produces small, black, pepper-like resting structures called cleistothecia. These structures serve as overwintering structures and also allow the fungus to survive in the absence of a suitable plant host. Cleistothecia are found in plant debris and are often the primary sources of inoculum in the spring. The powdery mildew fungus can also survive the winter as hyphae or fungal strands in infected buds.

One approach to managing powdery mildew is to plant resistant varieties. However, since resistance can be variable because there are many strains of the powdery mildew fungus, it is important to plant varieties known to be resistant in this area. Some cultivars with resistance to powdery mildew include Tropicana, Double Delight, Sonia, and Queen Elizabeth. Powdery mildew may also be reduced by following a good sanitation program that includes removing symptomatic leaves as soon as they appear. Leaves should be removed and immediately placed in a plastic bag to avoid spread of the powdery spores to other plants. It is also effective to remove all fallen leaves and plant debris in the fall. Diseased canes should be pruned back to healthy wood in the spring, prior to budbreak. It is also helpful to have sufficient space between plants to ensure good air circulation and reduce humidity levels. Plant vigor should be maintained by following a program of sound cultural care. Fungicide sprays can supplement other options for powdery mildew control. Among the compounds

registered in Connecticut are thiophanate methyl, chlorothalonil, triforine, triadimefon, sulfur, potassium bicarbonate, horticultural oil, and mancozeb. Consult the label for dosage rates and safety precautions. Applications can be made when symptoms first appear and continued as long as conditions are favorable for disease development.

DOWNY MILDEW

Downy mildew, caused by the fungus-like organism *Peronospora sparsa*, is a highly destructive disease of rose. Fortunately, it is somewhat sporadic in occurrence in Connecticut. Disease development is favored by cool, wet conditions and it can occur in landscape and glasshouse roses. Symptoms can develop on all above-ground parts of the plant including leaves, stems, peduncles, calyxes, and petals. However, leaf infections are the most common and are relatively easy to recognize. Infected leaves develop purple to red, angular spots or blotches that are readily visible on the upper surface. These symptoms are often accompanied by yellowing, necrosis, and premature leaf drop. In some cases, these symptoms can be confused with those associated with contact injury or phytotoxicity due to misapplied pesticides. Defoliation can be extensive when infections are heavy. Under conditions of high humidity, a purplish-gray mass of spores of the pathogen develops on the undersurfaces of the infected leaves. Downy mildew can be distinguished from powdery mildew on the basis of where the sporulation occurs: the downy mildew pathogen only sporulates on the abaxial (lower) surface of the leaf; the powdery mildew fungus usually sporulates on the adaxial (upper) surface of the leaf first but can be found sporulating on both leaf surfaces. Small, purplish-black lesions can also develop on canes and peduncles. These are often confused with those associated with black spot. The pathogen overwinters as mycelium in infected canes and as resting spores (oospores) in plant debris and stems.

Downy mildew can be managed by following a program of good sanitation that includes removing infected leaves as soon as they appear and removing all fallen leaves and plant debris in the fall. Diseased canes should be pruned back to healthy wood in spring prior to budbreak. It is also helpful to have sufficient space between plants to ensure good air circulation and reduce humidity levels. Steps to avoid overhead irrigation and watering early in the day help to minimize conditions favorable for disease development. Plant vigor should also be maintained by following a program of sound cultural care. Fungicide sprays can supplement other options for downy mildew control. Among the compounds registered in Connecticut are copper hydroxide and mancozeb. Consult the label for dosage rates and safety precautions. Applications can be made when new growth first appears and are continued as long as conditions are favorable for disease development.

BOTRYTIS BLIGHT

Botrytis blight, caused by the fungus *Botrytis cinerea*, is a very common disease of rose. This fungus is cosmopolitan and has an extremely broad host range. Symptoms develop on all above-ground parts including flowers, buds, canes, and growing tips. Disease development is favored by periods of cool, cloudy, humid weather. The most diagnostic symptom of Botrytis blight is the presence of grayish-brown, fuzzy growth on

the surfaces of infected plant parts. Small, tan flecks or patches appear on flower petals and flower buds. Infected flower buds may droop and fail to open. *Botrytis* can also infect the stub ends of pruning cuts and any wounds from cutting. These types of infections can result in blighting of canes as the fungus produces sunken, tan-brown cankers that girdle the canes. *Botrytis* can effectively survive on all types of plant debris.

Sanitation is critical for management of Botrytis blight and includes removing spent flowers and infected leaves as soon as they appear and removing all fallen leaves and plant debris in the autumn. Diseased canes should also be pruned back to healthy wood in spring prior to budbreak. It is also helpful to have sufficient space between plants to ensure good air circulation and reduce humidity levels. Steps to avoid overhead irrigation and watering early in the day help to minimize conditions favorable for disease development. Plant vigor should also be maintained by following a program of sound cultural care. Fungicide sprays can supplement other options for control of Botrytis blight. Among the compounds registered in Connecticut are captan, chlorothalonil, copper sulphate pentahydrate, iprodione, mancozeb, potassium bicarbonate, and thiophanate methyl. Consult the label for dosage rates and safety precautions. Applications can be made when symptoms first appear and are continued as long as conditions are favorable for disease development.

CANKER (BRAND AND COMMON CANKER)

Roses are susceptible to several types of fungal stem cankers. The two most common causal agents are *Coniothyrium wernsdorffiae* and *C. fuckelii,* that cause brand canker and common canker, respectively. Both fungi infect through wounds from pruning, insects, and other types of mechanical injuries. Symptoms are confined to the canes or stems and vary in size and other characteristics, depending upon the causal agent. Cankers often begin as small, yellow or dark, reddish spots. The affected areas gradually enlarge and become distinctly brown or reddish-brown in the centers. With brand canker, the canker margin appears reddish-brown or purple whereas common canker has a dark brown margin. Cankered areas are often readily visible from the healthy green of the unaffected portion of the cane. When cankers girdle or encircle a cane or stem, they result in wilting and death of everything beyond the canker. Small, black flecks can develop in the centers of the cankers and are fruiting structures of the causal fungi.

Canker diseases can be managed by following a program of good sanitation. Diseased canes should be pruned back to sound, healthy wood in the spring prior to budbreak. Proper pruning cuts using sharp, clean equipment are important to maximize healing. Equipment can be disinfested with a 10% solution of household bleach (1 part bleach: 9 parts water), 70% alcohol, or one of the commercially available compounds such as Greenshield®. Plant vigor should also be maintained by following a program of sound cultural care. It is helpful to avoid injuries and to provide adequate winter protection. Fungicides are not effective for control of canker diseases.

RUST

Rose rust is a fungal disease caused by several species of *Phragmidium.* Symptoms can develop on leaves and any other green parts of the plant. Under favorable conditions, rust symptoms can appear on the entire plant. Small, orange pustules develop on both leaf surfaces in early spring. These gradually enlarge and become more pronounced on the abaxial (lower) surface of the leaf. Chlorotic or mottled areas can also develop on the adaxial (upper) surface of the leaf. These areas usually develop directly over the pustules on the lower surface. Young stems and sepals can also become infected. By late-summer or early-fall, the pustules turn black and contain the spores for winter survival. Heavy infections can result in premature defoliation. However, cultivars vary greatly in susceptibility and in their reactions to infection. Disease occurs after spores are transmitted through the air, land on leaves and infect the leaves through stomates. Relatively cool temperatures, high moisture, and high levels of relative humidity are conducive for rust development. Rust fungi overwinter on dead leaves, plant debris, and infected canes.

Rust diseases can be managed by following a good sanitation program that includes removing infected leaves as soon as they appear and removing all fallen leaves and plant debris in the fall. "Rusted" canes should also be pruned back to healthy wood in spring prior to budbreak. It is also helpful to have sufficient space between plants to ensure good air circulation and to avoid overhead irrigation or water early in the day to minimize conditions favorable for disease development. Plant vigor should also be maintained by following a program of sound cultural care. When available, it is helpful to plant rust-resistant cultivars or species. Fungicide sprays can supplement other options for rust control and a number of compounds are registered in Connecticut. Lime sulfur is registered as a dormant spray. The fungicides mancozeb, chlorothalonil, myclobutanil, and triforine are effective for control of rust during the growing season. Consult the label for dosage rates and safety precautions. Applications can be made when new growth first appears and are continued as long as conditions are favorable for disease development.

CROWN GALL

Crown gall is caused by the bacterium *Agrobacterium tumefaciens*. This disease is commonly recognized by the presence of galls or swellings on the main stem at or slightly below the soil line. Galls can also form on roots, and more infrequently, on aerial portions of the plant. Crown galls are often irregular in shape, have no internal structure or organization, and vary in size. Young galls are light green or off-white and soft. As these galls age, they darken to brown or black and become hard and woody. Roses infected with crown gall react in many different ways. Some plants appear stunted, others have poor foliage and produce few flowers or flowers of poor quality, and others are killed. The locations of the galls appear to have a significant impact on the symptoms exhibited by the infected plant. For example, a single gall at the base of a stem may be more damaging than several galls located on roots or aerial canes. The bacterium infects through wounds (e.g., from pruning, cultivating, insect chewing, or heaving in frozen soil). It can also be transmitted by wounds made with infested tools. Crown gall bacteria survive in galls and in the soil without a plant host for at least two years.

Prevention and sanitation are critical for managing crown gall. It is important to use healthy, disease-free transplants and to carefully inspect plants prior to planting. It is helpful to avoid injuries to the roots and crown during planting and cultivating. Canes with galls can be pruned back to sound, healthy wood. Proper pruning cuts using sharp, clean equipment are important to maximize healing. Equipment can be disinfested with a 10% solution of household bleach (1 part bleach: 9 parts water), 70% alcohol, or one of the commercially available compounds such as Greenshield®. Rootstocks differ in their susceptibility to crown gall. Among the more resistant types are *Rosa multiflora* and *R. manetti*. Plant vigor should also be maintained by following a program of sound cultural care. Control of crown gall with biological control agents has yielded mixed results. The bacterium *Agrobacterium radiobacter* strain K84 is registered for biocontrol and has occasionally been successful as a preplant dip or spray. There are no effective chemical controls for this disease.

MOSAIC

Rose mosaic is caused by a complex of several viruses including Prunus Necrotic Ringspot Virus (PNRSV) and Apple Mosaic Virus (AMV). Symptoms are highly variable and depend upon time of year, temperature, species, cultivar, and the specific viruses infecting the plant. Characteristic leaf symptoms appear as wavy or zigzag, chlorotic lines but symptoms may also appear as ringspots and mottled patterns. Yellow watermarks, vein clearing, or dull yellow blotches may also be indicative of infection. Some infected plants may appear stunted and weak and others may show no symptoms at all. Reductions in flower numbers and size, distortion, and reduced winter hardiness have also been reported to be associated with infection. Symptoms are often most pronounced in spring and early summer and may not be present in summer, possibly due to temperature. Rose mosaic is not readily transmitted in nature since no insect vectors have been identified. However, it is spread when infected buds, scions, or rootstocks are grafted onto healthy plants. Once plants are infected with rose mosaic, they cannot be cured.

Rose mosaic can be avoided by purchasing healthy, certified virus-free planting material. It is also prudent to scout for symptoms on a regular basis and to remove and destroy infected plants as soon as they are identified.

WINTER INJURY

Winter injury results from many environmental factors that have little in common other than they occur during the winter. Examples 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, unusually warm midwinter temperatures, extended periods of extreme or abnormally cold temperatures, and drying winds. 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. Another important characteristic of winter injury is that quite often the symptoms are not evident until sometime after the injury has occurred. Symptoms of winter injury are highly variable and are manifest as buds that fail to open in spring or shoots that wilt and collapse shortly after emergence or suddenly collapse during the heat of the

summer. In some cases, canes are blackened and dead by spring.

Winter injury can be minimized by maintaining plant vigor by following a program of sound cultural care. For example, one of the most effective defenses against winter injury is to stop fertilizing early enough in the season so the plants have a chance to go into natural dormancy. In spring, any dead canes that can serve as sites for secondary invaders or opportunistic pests should be pruned and removed from the planting. Winter protection in the form of winter mulching is also helpful for bud-grafted plants such as hybrid teas. It is usually not necessary for species, shrub, old garden, or climbing roses. Roses can be mulched with loose soil, compost, or leaves mounded around the base after the first hard frost. The goal is to protect the bud union from the weather extremes of the winter. Winter mulch should be removed in early spring when new growth begins. It is also important to select cultivars or species of rose that are known to be hardy in Connecticut.

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COMMON PROBLEMS OF RHODODENDRON, MOUNTAIN LAUREL, AND AZALEA

The broadleaved evergreens rhododendron, mountain laurel, and azalea are commonly affected by several physiological disorders and diseases in Connecticut.

LEAF SPOTS: Fungal leaf spots appear as dead areas of tissue scattered over the surface of the leaf. They usually have distinct margins, often with brown, black, tan, or reddish centers, and darker margins. The spots can vary in size from pin-head to those that encompass the entire leaf. Management of fungal leaf spots can be achieved using a variety of strategies. Leaf spots are rarely serious enough to warrant chemical control and are often effectively controlled 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 good cultural methods that promote plant vigor. These include proper watering and fertilizing, appropriately timed pruning, and insect control.

In some cases, leaf spots can become serious and result in injury (e.g., branch and twig dieback) or even plant death. This is especially problematic on weakened or stressed plants. In such cases, chemical control is often necessary, especially in cool, wet springs. There are several fungicides registered for use in control including thiophanate methyl, chlorothalonil, and mancozeb. The pesticide label will contain information for use with specific plant hosts and fungi, dosage rates, and safety precautions. Since most leaf-spotting fungi infect in spring as new leaves are emerging, the first fungicide spray is applied at budbreak. Two or three additional sprays are subsequently applied at 7-14 day intervals, depending upon the pesticide label. Additional applications may also be necessary in unusually wet springs. When symptoms are visible on the new leaves, it is usually too late for chemical control.

WINTER INJURY: Winter injury or winter drying of broadleaved evergreens commonly occurs on shrubs 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 shrubs to secondary or opportunistic pests. Causal factors

are diverse but include sudden temperature fluctuations, excessive or late season fertilization, lack of snow cover, and late spring frosts. Often the effects do not show up immediately. Symptoms can be varied but are usually characterized by marginal or tip browning of leaves, dieback of growing tips, and bark splitting. Water evaporates from the leaves on windy or on warm, sunny days and cannot be replaced since the water in the soil is still frozen or unavailable to the plant roots. While there is no cure for this physiological disorder, there are steps to help minimize the effects of winter injury. These are 1) select an appropriate site for planting and maintain shrub vigor by good cultural practices; 2) deep-water shrubs before the ground freezes in the fall and mulch around the base of the shrub 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 that encourages growth that does not harden off properly; 4) prune out dead or dying branches or twigs in spring; and 5) construct physical barriers such as wind breaks to minimize drying winds.

CHLOROSIS: Broadleaved evergreens 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, the shrubs are unable to absorb iron and the leaves yellow and often abscise. This physiological disorder can usually be corrected by treating the soil with an iron chelating compound or by lowering the soil pH. Under conditions of heavy or waterlogged soils, leaves yellow because plants are unable to absorb nutrients since feeder roots have been damaged by excessive soil moisture and lack of oxygen. This condition is often irreversible if damage is extensive. However, efforts to improve soil texture and drainage will help if the problem is recognized early.

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DE-ICING SALTS: DAMAGE TO WOODY ORNAMENTALS

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. 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. Salt can injure plants at any time 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.

SALT 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. 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. 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.

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 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 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 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 that 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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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 only 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 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. 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. A diagnostic feature of Diplodia blight is the presence of stunted, straw-colored shoots with short needles and resin flow. In trees that are relatively free from stress, tip blight only kills the current-season buds and shoots and second-year cones. Older twigs and branches are damaged only 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.

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. 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.

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 the

disease since they contribute considerable fungal inoculum. Fruiting structures of the fungus are readily seen as small, black bodies on the cone scales.

Diplodia blight is favored by wet spring weather, 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 that 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 control 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 control 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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DISEASE PROBLEMS IN CONNECTICUT CHRISTMAS TREE PLANTATIONS 2006-2007

Many Christmas tree plantations throughout Connecticut were challenged by the wet, cool 2006 growing season. Fungal diseases and weather-related stresses were visible in many plantations. Repeating (autoecious) spruce needle rust was widespread and severe on plantation as well as landscape trees throughout the state. Needlecasts, blights, and root rots also continued to be problematic for several types of conifers. Last year's wet, dry growing season, a relatively mild winter, a cool, wet spring, and a wet summer all contributed to tree problems during the 2006 growing season.

Diseases caused by fungi are characteristically more serious during cool, wet spring and summer weather, ***exactly*** the conditions of this growing season. Since the conditions were favorable for fungal diseases this spring, depending upon the prevalence and severity of a particular disease(s) in a plantation, it might be prudent to allow extra time to scout for symptoms during late winter and early spring in order to anticipate possible problems and the need for early-season sprays for control during the upcoming 2007 season.

CURRENT DISEASE PROBLEMS:

The key problems observed on conifers in 2006 are listed as follows.

A. Abiotic (caused by nonliving agents)
- Winter Injury
- Excess Water

B. Biotic (caused by living agents)
- Autoecious (Repeating) Spruce Needle Rust
- Botrytis Blight
- Sirococcus Blight
- Rhabdocline Needlecast
- Rhizosphaera Needlecast
- Phytophthora Root Rot

A. ABIOTIC PROBLEMS: (caused by nonliving agents)

Synopsis of this Season's Weather:
This spring and early summer were quite a contrast to last year's extremely hot and dry conditions. Cool, cloudy, wet conditions prevailed throughout May and into early summer. These conditions resulted in free moisture on the developing needles and shoots and satisfied the requirements for many types of fungal infections. Budbreak was also prolonged by cool temperatures in May so tissues were extremely susceptible to infection for longer than usual.

Also problematic for many trees were the October 2005 rains after the drought of the 2005 growing season. These fall rains resulted in problems with dormancy for many trees. These conditions were followed by quirky winter weather with sudden drops in temperature, extreme fluctuations in temperature, periods of prolonged low temperatures, and drying winds. All of these conditions resulted in some damage to trees of all ages.

I. WINTER INJURY

The winter of 2005-2006 was fairly mild and characterized by a few prolonged periods of extremely cold temperatures contrasted by record high temperatures in January. Winter injury or drying results from factors that contribute to a water deficit in the tree. 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 water from frozen soil. Prolonged periods of extremely cold temperatures also result in winter injury, specifically injury to bark and cambial tissues. This injury can be lethal and is visible as dieback or browning of branches in late winter or early spring as trees begin to flush. Injury can also be "sub-lethal." When this occurs, branches on affected trees suddenly collapse or develop brown branches in the middle of the growing season. In these cases, damage to the bark and cambium is not evident in spring but once demands for water and nutrients are placed on the injured tissues in mid to late-summer, affected tissues collapse.

1. Symptoms:

Symptoms of winter injury include tipburn, chlorotic mottling or uniform yellowing of needles, and tip or branch dieback. Damage often appears on one side of the tree or on one branch, usually the side facing prevailing winds. In many cases, one-third to one-half of each needle is often browned. All species of conifers are susceptible, but newly transplanted trees are especially susceptible. Depending on the extent of the damage, visible symptoms often do not appear until the following spring or even into the summer. In some years, a distinct line is visible in a plantation where the snow cover has protected the lower branches of the trees from drying and injury. Winter injury and desiccation also weaken trees and make them more susceptible to needlecasts, blights, root diseases, and opportunistic pests.

2. Management:

While there is no cure for this disorder, steps to help minimize the effects of winter injury include:

- Select an appropriate site for planting and use good planting techniques to ensure maximum root growth.

- Maintain tree vigor by following sound cultural practices.
- Give trees, especially new transplants, a deep watering before the ground freezes in the fall and mulch around the base of the trees to maintain moisture in the root zone.
- Fertilize at the proper time and rate as determined by a soil test--avoid excessive nitrogen and late-summer and early-fall fertilization.
- Prune dead or weakened branches prone to secondary problems.

II. EXCESS WATER OR WET SOIL

The October 2005 rains after a long dry spell created problems for root health. This was compounded by numerous periods of prolonged rainfall during the 2006 growing season. Waterlogged soils limited growth of new roots and inhibited the ability of existing roots to absorb water. The waterlogged conditions in October came when temperatures were warm enough for sporulation, spread, and infection by *Phytophthora.* These conditions may have contributed to new infections of highly susceptible species such as Fraser fir. Refer to section on Phytophthora root rot that follows.

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. Feeder roots are particularly sensitive to flooding 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 species and the flooding conditions. This can occur on plants in obviously wet sites and on those in marginal sites or soils such as in areas where high clay content in the soil impedes drainage. Most trees cannot grow in waterlogged soils for very long and can die if flooded for only a few days during the growing season.

1. Symptoms:

Symptoms include dwarfing of needles, general chlorosis, wilting, needle drop, and dieback. These 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. 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 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.

2. Management:

Strategies for minimizing wet soil problems include following some *preventative* measures.

- Select an appropriate site and use proper planting practices.
- Follow cultural practices that maintain plant vigor and stimulate growth.
- Select appropriate species for soil and site conditions: intermediately water-tolerant (e.g., balsam fir) vs. water-intolerant (e.g., hemlock, white pine, blue and white spruce).
- Prune dead or dying tissues to minimize secondary invaders.

B. BIOTIC PROBLEMS: (caused by living agents such as fungi or bacteria)

During the 2006 season, a needle rust, two tip blights, several needlecasts, and one root disease were diagnosed in Christmas tree plantations in Connecticut. These fungal diseases were autoecious (repeating) spruce needle rust, Botrytis blight, Sirococcus blight, Rhabdocline needlecast of Douglas-fir, Rhizosphaera needlecast of spruce, and Phytophthora root rot. The wet conditions and relatively high frequency of some of these diseases during the 2005 season provided key sources of overwintering inoculum for spring 2006. Since we had a recurrence of many diseases during the 2006 season, we can expect some level of overwintering inoculum in many plantations. As a consequence, it might be wise to scout for symptoms in late winter and early spring of 2007 so you can anticipate the need for fungicide sprays. This will be especially important for trees that will be ready to sell in 2008.

I. AUTOECIOUS (REPEATING) SPRUCE NEEDLE RUST

1. **Causal Agent: *Chrysomyxa weirii***
2. **Key Hosts: blue and white spruce**
3. **Symptoms and Spread:**

Unusually severe and widespread outbreaks of this rust occurred on spruce trees in landscapes, production nurseries, and plantations during the 2006 season. This fungal disease has been present in the state for years but it reappeared in 1996 and its incidence and severity have been on the increase over the past few years. 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. 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 the heteroecious Chrysomyxa rusts appear in mid to late-summer. Blue spruce is highly susceptible to this disease.

Symptoms first appear as yellow spots or flecks on needles in late winter and early spring. These spots eventually develop into pustules or blisters (telia) and 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 needles of the same tree or onto those of adjacent trees. 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. As with most diseases that are not fatal but result in needle drop, repeated defoliation may retard growth and reduce marketability.

4. **Management:**
   a. 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.
   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, Daconil Ultrex, 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 budbreak is slow and the weather is cool and there is enough free moisture on the needles for infection (as in May 2005), up to 5 sprays may be necessary.

II. BOTRYTIS BLIGHT

1. **Causal Agent: *Botrytis cinerea***
2. **Key Hosts: all conifers, especially spruce and fir**
3. **Symptoms and Spread:**

Botrytis blight appeared on a number of conifers in both plantations and landscapes but white and blue spruce and Douglas-fir were particularly affected. *Botrytis* was observed on tender, succulent tips that had emerged during the extended cool, relatively moist May weather of 2006.

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. This spring, many conifers exhibited symptoms of *Botrytis* infection. 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. 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.

4. **Management:**
   a. 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.
   b. Avoid overcrowding to allow for good air circulation.
   c. Avoid overhead irrigation or water early in the day so the foliage has a

chance to dry.

d. 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;

e. 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: ferbam (Ferbam), mancozeb (Protect), chlorothalonil (Daconil, Bravo), chlorothalonil + fenarimol (TwoSome), thiophanate methyl (Cleary's 3336), and copper sulphate pentahydrate (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.

III. SIROCOCCUS BLIGHT

1. **Causal Agent: *Sirococcus conigenus***
2. **Key Host: many conifers including Douglas-fir and blue and white spruce**
3. **Symptoms and Spread:**

Higher than usual incidences of Sirococcus blight were observed on Douglas-fir and blue spruce in plantation and landscape trees this year. This level of disease was likely associated with the weather this spring. 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 1-year-old twigs in midsummer. Affected shoots often appear at random within the canopy of a tree. This disease is often confused with Botrytis blight but Sirococcus usually shows up later in the season. However, symptoms are sometimes more pronounced in the lower portions of older trees. This is because low light levels increase the susceptibility of tissues to infection. Blue spruce is highly susceptible and 1-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 or water during spring and into summer. Infections occur when conidia land on succulent tissues of newly emerging shoots 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 were exactly the conditions throughout Connecticut this spring. Infections result in stunting or disfigurement of the growing tips.

4. **Management:**
   a. Use healthy stock and maintain tree vigor with good weed control, proper fertilization, and attention to planting site.
   b. Rogue severely symptomatic trees.
   c. Prune and remove any dead or dying branches when the bark is dry.
   d. 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;
   e. Use less susceptible varieties, when possible.
      - blue spruce is highly susceptible;
   f. Fungicide sprays.
      - in *all* cases, coverage is **very** important!
      - chlorothalonil (Bravo, Daconil 2787, Daconil Ultrex, Daconil Weather Stik), chlorothalonil + fenarimol (TwoSome), and thiophanate methyl + chlorothalonil + mancozeb (Spectro 90 WDG), and azoxystrobin (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.

IV. RHABDOCLINE NEEDLECAST

1. **Causal Agent: *Rhabdocline* spp.**
2. **Key Host: Douglas-fir**
3. **Symptoms and Spread:**

Outbreaks of Rhabdocline needlecast of Douglas-fir were spotty and sometimes severe throughout the state in both Christmas tree plantations and in landscape plantings again this spring. In some plantations, the disease was so severe that blocks appeared distinctly reddish-brown from a distance. The slow but steady increase in Rhabdocline over the past few years is probably the result of the buildup of inoculum over several growing seasons. This year, the combination of the elevated levels of inoculum from symptomatic trees and optimum conditions for infection may have resulted in significant infections of newly developing needles in some plantations. If you had outbreaks of Rhabdocline this season, be sure to scout for symptoms in winter and in early spring 2006 in order to be ready to spray to manage this disease.

Rhabdocline needlecast was first reported in the 1920's and has steadily increased in both incidence and severity for the past eight years. This increase can be attributed to a number of factors including the weather, increased planting of Douglas-fir and associated seed sources, and environmental stress. The primary damage associated with this important disease is defoliation that leads to suppressed growth and to value loss in Christmas trees.

Symptoms of Rhabdocline 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 be confused with feeding damage from the Cooley spruce gall adelgid.) These chlorotic spots gradually turn reddish-brown and can range from 1-2 mm or can encompass the entire needle. A distinctive diagnostic characteristic is the sharp border between the healthy green tissue and the infected brown tissue. Discolored needles are most conspicuous in early spring. Symptoms are often most severe on 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. In late spring, fruiting structures of the fungus develop beneath the epidermis on the lower surface of the needle. The epidermis eventually ruptures and splits open, usually in two longitudinal lines, and exposes the spores of the fungus. These spores are carried by rain and wind to newly expanding needles. When the spores land on immature needles they germinate, penetrate the cuticle, and begin to grow within the needle. Even though the fungus has infected the needle, no obvious external symptoms are evident until considerably later, by fall or winter. There is only one infection period per year and infection is favored by cool, moist weather and periods of rain. Rhabdocline needlecast is most damaging in plantations where weed growth, close spacing of trees, or dense foliage induced by shearing impede air circulation and prolong wetness on lower branches.

4. **Management:**
   a. 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.
   b. Select the appropriate planting site (slopes with good air drainage) and maintain good weed control to promote good air drainage and dry conditions on lower branches.
   c. Rogue severely symptomatic trees.
   d. Prune and remove any dead or dying branches. There is no need to remove prunings from the plantation floor since the fungus cannot mature on branches once they are cut.
   e. 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;
   f. Use resistant varieties when possible.
      - seed sources and individual trees ***vary greatly*** with regard to susceptibility;
        most resistant- Shuswap, Pillar Lake;
        moderately resistant- Santa Fe, Silver Creek, Coville;
        most susceptible- San Isabel, Lincoln, Apache, Cibola, Kaibob, Coconino;
   g. Fungicide sprays.
      - in *all* cases, coverage is **very** important!

- chlorothalonil (Bravo, Daconil 2787, Daconil Ultrex, Daconil Weather Stik), chlorothalonil + fenarimol (TwoSome), and mancozeb (4 Flowable Mancozeb, Protect T/O) 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 for additional sprays at 7-14 day intervals depending on rainfall. Sprays should continue until needles are fully elongated and conditions are no longer favorable for disease.

V. RHIZOSPHAERA NEEDLECAST

1. **Causal Agent: *Rhizosphaera kalkhoffii***
2. **Key Hosts: blue spruce, occasionally white spruce**
3. **Symptoms and Spread:**

Rhizosphaera needlecast of blue and white spruce was also prevalent in 2005 in plantations and landscapes, especially on trees that had been stressed. The situation with this disease is similar to that of Rhabdocline needlecast. The symptoms this spring (2006) were the result of last year's infections during the wet spring 2005 conditions.

This needlecast fungus has been causing increasing damage on spruce, especially blue spruce, throughout Connecticut. One reason for this dramatic increase can be explained by the fact that Rhizosphaera needlecast is more severe in drought stressed trees. Although some trees are killed, the primary damage has been premature needlecast. The fungus attacks needles on the lower branches first and gradually progresses up the tree. On severely diseased trees, the infected needles usually fall during their second summer, leaving only the current-season's growth on the bottom half. Under epidemic conditions, lower branches may be killed by the fungus.

Current-year needles become infected in May and June but symptoms do not appear until late fall or the following spring. Diagnostic symptoms may develop in early September but typically occur in spring: infected needles turn a distinctive lavender or purplish-brown. At that time, pinpoint black fruiting bodies of the fungus appear in the stomata of the infected needles. These can be seen with a hand lens and appear as fuzzy, black spots instead of white stomates. During periods of rain and wet weather, spores of the fungus are released and are rain-splashed onto newly developing needles where infection occurs. The infection period for this disease can be quite long since infections begin in spring and can continue until autumn.

Rhizosphaera needlecast is often first evident in stands that are naturally moist or that have poor air drainage or in stands adjacent to taller trees that reduce wind-drying of the foliage. *Rhizosphaera* typically infects newly grown needles of the current-season but can attack needles of any age that are dying or stressed by other plant pests or environmental factors.

4. **Management:**
   a. Use healthy stock and maintain tree vigor with good weed control, proper fertilization (as determined by a soil test), and attention to planting site.
   b. Prune and remove any dead or dying branches. Remove *all* prunings from the plantation floor since the fungus can mature on branches that are cut.
   c. 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;

d. Use resistant varieties, if possible.
   - blue spruce is most sensitive, white spruce is intermediate, and Norway spruce is relatively resistant;

e. Fungicide sprays.
   - in *all* cases, coverage is **very** important!
   - chlorothalonil (Bravo, Daconil 2787, Daconil Ultrex, Daconil Weather Stik), chlorothalonil + fenarimol (TwoSome), chlorothalonil + thiophanate methyl (Spectro), elemental copper (Basicop), mancozeb (Protect), and copper hydroxide (Kocide) are registered for use;
   - refer to the label for information on dosage rates and safety precautions;
   - applications can be made when new shoots are approximately 1½" long and again 3 weeks later;
   - additional applications may be necessary in years with excessive rainfall.

VI. PHYTOPHTHORA ROOT ROT

1. **Causal Agent: *Phytophthora* spp.**
2. **Key Hosts: hundreds of woody plants including most conifers, especially true firs such as Fraser fir**
3. **Symptoms and Spread:**

The combination of dry conditions of 2005 followed by the October rains of 2005 provided optimum conditions for this disease, especially on highly susceptible species like Fraser fir. Aboveground symptoms of this disease are not very distinctive, a characteristic typical of most root rot diseases. Included among the symptoms of Phytophthora root rot 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.

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 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. *Phytophthora* can be dormant in soil for many years as mycelial strands or as chlamydospores. When these dormant structures are subjected to warm and saturated soils, even for a few hours, this pathogen can be activated. These were the conditions present during and after the October rains of 2005 when soil temperatures were still greater than 54°F.

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 root 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.

4. Management:

a. Use healthy stock. Carefully inspect transplants from seedling beds prior to planting.
b. Avoid planting in poorly drained sites or take steps to modify or improve drainage.
c. Maintain vigor by proper fertilization (based on soil tests) and planting practices; avoid excessive irrigation.
d. Rogue and remove symptomatic trees.
e. Fungicides:
   - ***NOTE:*** fungicides cannot be used in a curative fashion- 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.

OTHER DISEASES:

Numerous other diseases that can occur in Connecticut Christmas tree plantations are not covered in this handout. Please refer to previous editions of *Disease Problems in Connecticut Christmas Tree Plantations* for more detailed information about many of these diseases. Copies are available upon request. This handout is updated on a yearly basis.

SELECTED REFERENCES:

There are a number of good reference books on diseases and insect pests of Christmas trees and conifers. As follows is a selection of moderately priced (i.e., affordable) ones with the bonus of having good, color photographs.

Christmas Tree Pest Manual, 2nd Edition. 1998. D. G. McCullough, S. A. Katovich, M. E. Ostry, and J. Cummings-Carlson. Michigan State University.
143p. $20.00
Extension Bulletin E-2676
Order From: MSU Bulletin Office
10-B Agricultural Hall
Michigan State University
East Lansing, MI 49924-1039
517-355-0240

Christmas Tree Diseases, Insects, & Disorders in the Pacific Northwest:

Identification and Management. 1997. G. A. Chastagner. Washington State University.

154p. $25.00 + $4.00 shipping
Bulletin MISC0186
Order From: Washington State University Cooperative Extension
Bulletin Office
P. O. Box 645912
Pullman, WA 99164-5912

Compendium of Conifer Diseases. 1997. E. M. Hansen and K. J. Lewis. APS Press, St. Paul, MN. 124p. $49.00

ISBN 0-89054-183-3
Order From: APS Press
The American Phytopathological Society
3340 Pilot Knob Road
St. Paul, MN 55121-2097
1-800-328-7560
Website- http://www.shopapspress.org

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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).

Figure 1. Necrotic spots on leaves.

Figure 2. Smoky, purple-brown rings on foliar lesions.

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 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

Figure 3. Progressive dieback of branches up the tree.

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.

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. Consult the label for dosage rates and safety precautions.

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DROUGHT, ITS AFTER-EFFECTS, AND MANAGEMENT STRATEGIES FOR WOODY ORNAMENTALS

During the past few years, symptoms of drought stress have been visible on many woody plants in landscapes, natural woodlots, and forests throughout Connecticut. Records at the Experiment Station's Lockwood Farm in Mt. Carmel reported abnormally low levels of precipitation in May, July, August, and September 2005. In fact, low precipitation has been a recurring problem since 1995, which was characterized as the worst drought in 30 years and as the driest summer since 1944. Rainfall deficits were also recorded for the growing seasons of 1997, 1998, 1999, 2001, and 2002. 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 at the Station website (http://www.caes.state.ct.us/).

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) nonwoody 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. Among the key secondary problems are:

1. Winter Injury-- Drought stressed woody ornamentals are not as winter-hardy as their healthy counterparts.

2. Root Problems-- Injured or weakened root systems are more susceptible to root rots.

Example:

a. Armillaria Root Rot- Causal Agent: *Armillaria mellea*
Hosts: many species including pine, fir, oak, maple

3. Cankers-- Weakened woody ornamentals have slowed "defenses" and wound healing is inhibited.

Examples:

a. Nectria Canker- Causal Agent: *Nectria* spp.
Hosts: many species, maple, birch

b. Hypoxylon Canker- Causal Agent: *Hypoxylon* spp.
Hosts: many species, oak

c. Bleeding Canker- Causal Agent: *Phytophthora* spp.
Hosts: many species, esp. beech

d. Botryosphaeria Canker- Causal Agent: *Botryosphaeria dothidea, B. obtusa*
Hosts: many species, oak, maple, crabapple

4. Wood Rots-- Slowed defenses limit compartmentalization and reaction to invasion by wood-rotting fungi.

Examples:

a. Fomitopsis on red spruce
b. Fomes on maple
c. Polyporus

5. Sensitivity to Pesticides-- Weakened woody ornamentals are more sensitive to pesticides; compounds that do not cause problems for healthy plants can result in phytotoxicity on drought stressed plants.

Examples: various herbicides, insecticides, and fungicides

6. Sensitivity to De-icing Salts-- Weakened woody ornamentals are more sensitive to de-icing salts, especially sodium chloride.

7. Miscellaneous Diseases-- An increase in the frequency and severity of several diseases has been associated with drought stress.

Examples:

a. Sphaeropsis Tip Blight-	Causal Agent: *Sphaeropsis sapinea* Hosts: pine, esp. two- and three-needled species
b. Rhizosphaera Needlecast-	Causal Agent: *Rhizosphaera kalkhoffii* Hosts: spruce, esp. blue spruce
c. Cytospora Canker-	Causal Agent: *Leucostoma kunzei* Hosts: spruce, esp. blue spruce
d. Verticillium Wilt-	Causal Agent: *Verticillium* spp. Hosts: many woody plants, esp. Japanese maple
f. Dutch Elm Disease-	Causal Agent: *Ophiostoma ulmi* and *O. novo-ulmi* Hosts: elm
g. Ash Yellows-	Causal Agent: Phytoplasma Hosts: ash, especially white and green ash
h. Elm Yellows-	Causal Agent: Phytoplasma Hosts: elm

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 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. Once stressed by drought, these trees quickly decline and often die.

STRATEGIES FOR MANAGING DROUGHT PROBLEMS:

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 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, too shallow, failure to remove or cut the burlap and/or the wire basket). When planting a tree, try to anticipate the water needs of that 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 mulches can be very helpful. 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 or too close to the base of the tree ("volcano" or "pyramid" mulches) can be harmful!

5. **Prune any dead or weakened tissues to avoid secondary problems--**

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 can be beneficial and can help to stimulate root growth and regeneration.

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EXCESS WATER PROBLEMS ON WOODY ORNAMENTALS

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 water-logging. 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 upon 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 upon the plant and are highly variable. These include epinasty or downward rolling of leaves, stem swelling, chlorosis or yellowing of the foliage, edema, 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 water-logging 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: 1) selection of an appropriate site and use of 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 (red maple, larch, green ash) vs. water-intolerant (crabapple, spruce, hemlock, yew, white pine); and 4) pruning dead or dying tissues to minimize secondary invaders and opportunistic pests.

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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 that 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 that 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 that 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 that 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) that 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 that 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 incorrect or overuse 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 Systemic Acquired Resistance (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 brightly-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
Gala	Jerseymac	Empire
Gingergold	Macoun	Liberty
Granny Smith	McIntosh	Priscilla
Idared	Northern Spy	
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	BPM	Keiffer
Bosc	Comice	Old Home
Hardy	Winter Nelis	
Max Red Bartlett		
Starkrimson		
Sensation Red Bartlett		

Rootstocks: Bartlett most susceptible on: *Pyrus betulaefolia, P. communis, P. calleryana*

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FUNGAL LEAF SPOTS OF TREES AND ORNAMENTALS

SYMPTOMS AND DISEASE DEVELOPMENT:

Fungal leaf spots are the most prevalent of plant diseases in the Northeast. Most, if not all, commonly grown trees and ornamentals are subject to attack by one or more leaf-infecting fungi. Leaf spot symptoms vary depending upon the plant host and the causal fungus. A typical leaf spot is a rather definitely delimited necrotic lesion, often with a brown, black, tan or reddish center and a darker margin. These spots vary in size from pin-head to those that encompass the entire leaf. Partial to complete defoliation of the tree or ornamental may occur under certain circumstances.

Although many different fungi are known to cause leaf spots, their disease cycles are often similar. In most cases, the causal fungus overwinters on fallen leaves. In spring, often in conjunction with rain and wet weather, spores are produced by the fungus and subsequently discharged and carried by wind or splashing rain to newly emerging leaves. Once on the leaf surface and with appropriate environmental conditions, the fungal spores germinate, penetrate the leaf, and cause infection. Leaf spots are generally favored by cool, wet weather early in the growing season. By the time symptoms are apparent, it is usually too late to apply fungicides for control.

CONTROL:

Control of fungal leaf spots can be achieved using a multifaceted approach. They are often effectively controlled by following good sanitary and cultural practices and are rarely serious enough to warrant chemical control. Since many of the leaf-spotting 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. Good plant or tree vigor should be maintained by proper watering and fertilizing (if necessary or as suggested by a soil test), appropriately timed pruning, and insect control. Leaf spots can become serious, causing permanent injury or even plant death, on weakened or stressed plants. In such cases, fungicide control is often necessary. Several fungicides are registered for use in control in Connecticut. Among these are thiophanate methyl, chlorothalonil, ferbam, and mancozeb. However, accurate diagnosis of the specific leaf spot is often necessary in order to select the most efficacious fungicide for control. The pesticide label will contain information for use with specific plant hosts and fungi, dosage rates, and safety precautions. Since most leaf-

spotting 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. Once again, when symptoms are visible on the leaves, it is too late for chemical control.

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GLOSSARY OF SELECTED PLANT PATHOLOGY TERMS

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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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 plants or symptoms?
3. What part(s) of the plant is affected?
4. What are the symptoms?
5. What were the past management practices, weather conditions, soil type, or site?

THE DIAGNOSTIC PROCESS:

As follows are steps that are helpful in the diagnosis of plant health problems.

Step 1. Identify the Tree (Plant)

- It is important to identify the plant 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 plant.
- What should the plant 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 plant?

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 plant 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 a 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, and 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 plants or symptoms?

- How many plants are affected? Are they of different species?
- Where are the plants located? A field, glasshouse, landscape, forest, or indoors

"in a house, etc.?"
- Is there a pattern to plants that are symptomatic? Is it associated with drainage patterns, soil type, etc.?
- How much of the plant is involved? (whole plant vs. part of the plant, new growth or growing tip vs. older tissues).

What part(s) of the plant 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, malformations, poor development and growth.
- If the whole plant 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?

Step 3. 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 it was 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.).

Step 4. Identify the Problem or Collect Samples to Submit to a Specialist for Identification
- Consult references or submit samples for professional diagnosis.

Step 5. 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 plant valuable? How old is the plant (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 plant 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 plant stunted from root damage, poor management, environment, disease, insects.

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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JUNIPER TIP BLIGHT

Tip blight and dieback of twigs on juniper and, more rarely on arborvitae, hemlock, true fir, and Douglas-fir, can result from any of several causes, biotic (living) and abiotic (nonliving). This problem is sometimes less serious as plants become older, although it can be found on established plants, especially those growing under crowded or stressed conditions.

SYMPTOMS AND DISEASE DEVELOPMENT:

Tips of branches affected by this problem turn brown or ash gray and often show progressive dieback. In extreme cases, the entire plant is killed. **Abiotic** causes of tip blight include winter drying and injury, drought, or other environmental stress. The **biotic** organisms associated with tip blight are the fungi *Phomopsis* and *Kabatina*. *Phomopsis* typically infects newly developing foliage in spring and gradually moves into the stem. Symptoms develop on the current year's foliage and are often evident by midsummer. *Kabatina* typically attacks wounded, year-old twigs and symptoms usually show up when foliage begins to regain its seasonal color in spring. *Kabatina* appears to require a wound, usually associated with insect activity, whereas *Phomopsis* is capable of directly penetrating healthy tissue. *Phomopsis* and *Kabatina* can overwinter in fruiting structures on infected twigs and both fungi may be present on affected shrubs.

In advanced stages of tip blights associated with fungi, small, black fruiting bodies can be found at the base of blighted twigs. However, twig death from abiotic causes can sometimes appear the same as the fungal-associated blights since fruiting structures of some saprophytic fungi (ones that colonize dead tissues) look like plant pathogens (fungi that cause disease). Therefore, the first step to an effective management strategy is to accurately identify the cause. Microscopic examination is necessary to distinguish *Phomopsis* from *Kabatina*. In some cases, there is a sharper line of demarcation between blighted and green tissue in twig blights from biotic than from abiotic causes.

MANAGEMENT STRATEGIES:

Control can be accomplished by following a multifaceted approach. Regardless of the cause, dead tissues should be pruned and removed from the area. Pruning should be done when the foliage is dry. When watering, avoid overhead irrigation and wetting the

foliage or water early in the day to encourage rapid drying. New plantings should be spaced 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 fertilizing, controlling insect infestations, and watering during any periods of drought. Since resistant cultivars are available, they should be considered for use and many species of juniper have been reported to be resistant to at least one of the tip blights. For example, *Juniperus chinensis* cultivars "Femina" and "Pfitzeriana" and *J. comminus* cultivars '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' and 'Pfitzeriana.'

Fungicide applications can supplement other control strategies **if** the cause is **biotic**. For control of *Phomopsis*, the fungicides thiophanate methyl and thiophanate methyl + mancozeb are registered for use. Sprays should be applied when new growth begins to emerge in spring, with follow-up applications at 7-10 day intervals (or according to label instructions) or until new growth is mature and dark green. *Kabatina* can be controlled with the fungicides mancozeb or thiophanate methyl + mancozeb. Applications typically begin in midsummer and continue when conditions are favorable (wet, cool, and cloudy). Since it is not uncommon for a plant to be infected with both fungi, the combination product of thiophanate methyl + mancozeb will control both diseases. All fungicide labels will contain information on dosage rates and safety precautions.

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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-fir, and environmental stress. The primary damage associated with this important disease is defoliation that 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 can range from 1-2 mm or can encompass the entire needle. A distinctive diagnostic characteristic is the sharp border between the healthy green tissue and the infected brown tissue. Discolored needles are most conspicuous in early spring. Symptoms are often most severe on 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. In late spring, fruiting structures of the fungus develop beneath the epidermis on the lower surface of the needle. The epidermis eventually ruptures and splits open, usually in two longitudinal lines, and exposes the spores of the fungus. These spores are carried by rain and wind to newly expanding needles. When the spores land on immature needles they germinate, penetrate the cuticle, and begin to grow within the needle. Even though the fungus has infected the needle, no obvious external symptoms are evident until considerably later, by fall or winter. 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; it can be managed through the combined use of culture, sanitation, resistance, and fungicide sprays. Cultural methods include use of healthy stock and maintenance 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 7-14 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 previous year's or two-year-old needles. Affected needles appear yellow or mottled and gradually turn brown, often with 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. With the naked eye, these bands look like "dirt." The fruiting bodies are structures of the fungus that grow right out of the 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 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 ft. 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 1, 2, or 3 seasons. Spores are disseminated by wind or splashing rain and infect newly emerging needles in late spring and early summer during shoot elongation. 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 but non-pathogenic fungus that grows on the honeydew or excrement of insects. 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, 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 3 weeks later. Additional applications may be necessary in years with excessive rainfall.

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THE *ON-LINE* PLANT PEST HANDBOOK
www.caes.state.ct.us

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. In 2006, 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, 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 website;
- **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 website;

HOW 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.

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POWDERY MILDEW

Powdery mildew is probably 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 rare 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 it can develop at anytime 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. 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. 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 disease begins and when it is detected helps explain reports of sudden "explosions" of disease when the percentage of infected leaves increases from 10% to 70% in one week.

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, including *Erysiphe, Leveillula, Microsphaera, Sphaerotheca,* and *Oidium.* These fungi are all obligate parasites that require living

hosts in order 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). Conidia are "powdery" and are readily disseminated by air currents. 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 cleistothecia. These structures serve as overwintering structures and also allow the fungus to survive in the absence of a suitable host. Cleistothecia are usually found in plant debris 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.

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:

Control of powdery mildew can be achieved using a multifaceted approach. This disease is often effectively controlled by following good sanitary and cultural practices and is rarely 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: *Trichoderma harzianum*
    - "Traditional" fungicides: triadimefon, thiophanate methyl, chlorothalonil, sulfur, and copper

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RAMORUM BLIGHT (a.k.a. SUDDEN OAK DEATH) IN CONNECTICUT

Sudden Oak Death is the popular name for an emergent and potentially destructive new disease in the United States. The name, Sudden Oak Death (SOD), was initially used to describe the rapid decline of many native tree species first observed by hikers in coastal California forests in the mid 1990s. Trees in decline included tanoak (*Lithocarpus densiflorus*), California coast live oak (*Quercus agrifolia*), and California black oak (*Quercus kelloggii).* In some sites, 100% of mature tanoaks and 45% of California coast live oaks had been killed by this mysterious disease. An unidentified fungus-like organism was isolated from infected trees by forest pathologists in 2000 but the identity of this organism (*Phytophthora ramorum)* was not confirmed until 2001. To date, natural infections are limited to the West Coast, which includes several coastal counties in California and one county in Oregon. More recently, *P. ramorum* has also been detected in nurseries in California, Washington, Oregon, and British Columbia. National concern regarding this disease was heightened during 2004 when several shipments of plants from nurseries in California and Oregon were distributed to many states, including Connecticut, and were later determined to test positive for *P. ramorum.* As a result of these contaminated shipments, there is justifiable concern that Connecticut forests and landscapes may have been exposed to this pathogen.

The significant devastation of tanoaks and other species in California forests, the discovery of a closely related strain of the pathogen in Europe, and our lack of experience in dealing with this relatively new organism foster high levels of anxiety and uncertainty in scientific and public communities nationally and internationally. We are unable to make accurate predictions with regard to spread and potential environmental impact of this introduced pathogen because of this limited understanding. Many have asked if *P. ramorum* could be as destructive as the organisms responsible for Chestnut Blight, White Pine Blister Rust, or Dutch Elm Disease. Although we know that these three non-native, introduced pathogens have a history of destroying chestnuts, white pines, and elms in forests and landscapes, it is just too early to assess the potential of *P. ramorum*. Quite simply, we don't know enough about the biology and genetics of this plant pathogen to answer this and many other questions. We need to proceed with caution.

CAUSAL AGENT

Phytophthora ramorum is a fungus-like organism, or oomycete, identified as the causal agent of SOD in 2001. A very similar organism had been reported as the cause of a foliar blight of rhododendron and viburnum in Germany and Holland in 1993 but had not been characterized at the time of the report. However, in 2001, scientists determined the two pathogens were the same species and named the organism. To date, two races or mating types of the pathogen have been described. Race A1 is commonly found in Europe and Race A2 is predominant in the United States, although isolated reports of A1 have been reported in several nurseries in the United States. *P. ramorum* is not a pathogen of humans or animals. In Connecticut, many other species of *Phytophthora* are commonly found in landscapes, forests, and production nurseries. Most of these are root-infecting, soilborne, and waterborne organisms with somewhat limited capability for aerial spread. However, while maintaining the soilborne and waterborne characteristics of its relatives, *P. ramorum* also appears to have a high capacity for significant aerial dispersal. It is this potential for aerial spread that makes this pathogen particularly destructive. *P. ramorum* produces several different morphological structures that are important for spread and survival, including sporangia, zoospores, and chlamydospores. Abundant sporangia (microscopic, football-shaped structures, often arranged in grape-like clusters on stalks) are produced aerially on the surfaces of infected plants. These structures are easily dislodged by wind, water, and physical contact. Sporangia produce the microscopic, biflagellate swimming spores called zoospores, which are capable of moving to other plants through water, soil, and splashing rain and irrigation water. Zoospores are fragile and short-lived. Chlamydospores are specialized resting structures that help *P. ramorum* survive adverse conditions. Laboratory experiments demonstrated that chlamydospores are very drought-resistant but aren't very tolerant of high temperatures. At present, a fourth reproductive structure called an oospore (a sexual reproductive structure commonly associated with other *Phytophthora* species), has not been found in the United States.

P. ramorum is a heterothallic organism, which means that two different mating types are required for sexual reproduction, genetic exchange, and production of oospores. Although sexual reproduction is not required for survival or multiplication of this pathogen, it adds a level of complexity to the organism. Because of the predominance of only one race (A2) in the United States, and another race (A1) in Europe, genetic exchange within this organism has only been observed under laboratory conditions. There is concern, however, that crossing of the two races A1 and A2 might create new, potentially more virulent hybrids since A1 and A2 differ in virulence and symptom expression. Thus, many questions remain unanswered regarding the biology, potential survival, or evolution of this newly encountered organism.

P. ramorum is considered to be a cool climate species with optimal growth at 68ºF. However, studies have demonstrated the ability of the organism to survive beyond these parameters, within the temperature range of 36 to 80ºF. Moisture is also important for survival, spread, and infection of *P. ramorum* as evidenced by natural infections of forests in coastal "fog belts" of California. Studies have shown that spores do not survive drying but survive for at least one month under moist conditions.

Numerous studies on survival parameters of this organism are ongoing.

HOST RANGE

The plant host range for *P. ramorum* is broad and extremely diverse. The breadth of this host range is a characteristic that helps to distinguish *P. ramorum.* Most other *Phytophthora* species usually have more limited host ranges. The host list for *P. ramorum* includes herbaceous and woody species, and there are currently 31 "officially proven" or regulated hosts and 37 "officially associated" hosts. Proven or regulated hosts are hosts for which scientific tests have been completed to confirm they are host plants of *P. ramorum.* Associated hosts are species that have been found to be naturally infected with *P. ramorum* and for which testing has not been completed. Up-to-date lists are available at: http://www.aphis.usda.gov/ppq/ispm/pramorum/pdf_files/usdaprlist.pdf. Examples of proven hosts include viburnum, Japanese pieris, several species of oak, Douglas-fir, and heather. The search for additional hosts is ongoing.

Greenhouse studies on seedlings of several important East Coast tree species were conducted at the USDA ARS Foreign Disease-Weed Science Laboratory, Frederick, MD. These studies demonstrated the ability of *P. ramorum* to infect and produce cankers on many of the species tested. Included in this study were chestnut oak, white oak, and northern red oak, species commonly found in Connecticut forests. These findings serve to heighten our concern for East Coast forests.

SYMPTOMS

The disease symptoms associated with *P. ramorum* are very diverse and primarily determined by the host species. Symptoms can range from oozing, killing cankers on trunks and branches to foliar symptoms. Two distinct sets of symptoms associated with *P. ramorum,* and the diseases associated with these symptoms, have been called Sudden Oak Death and Ramorum Blight (Ramorum Dieback, Ramorum Leaf Blight). The disease 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. Additionally, some species can exhibit both sets of symptoms. For example, *P. ramorum* can produce foliar symptoms as well as killing, bleeding cankers on tanoaks.

Unfortunately, disease symptoms characteristic of *P. ramorum* infections are often indistinguishable from other diseases or effects of insect problems that we frequently encounter in Connecticut woodlands and landscapes. Examples of some common look-alike problems are bacterial wetwood, boring insects, winter injury, mechanical injury, fungi, and other *Phytophthora* species, such as *P. cactorum*. Because there are many other tree and shrub diseases, injuries, and disorders that can cause similar symptoms,

diagnosis of Sudden Oak Death or Ramorum Blight can be very confusing. If you are in doubt about what is causing a particular symptom on a plant, The Connecticut Agricultural Experiment Station (CAES) can provide assistance and expert advice.

DISEASE SPREAD

Because of the nature of this potentially devastating new disease, in 2002 the U.S. Forest Service generated a risk map for the United States. Each state was given a high, moderate, or low risk rating based on three key risk parameters. These parameters included: 1) presence of known host plants in overstory and understory of forests and woodlands; 2) climate; and 3) whether or not the state had nurseries that receive any proven or associated hosts of *P. ramorum* from the West Coast. Connecticut was determined to be at moderate risk. Additional risk maps are currently being constructed to include more comprehensive parameters.

P. ramorum has the potential to be dispersed over long distances through shipments of infected nursery stock. This pathogen also has the potential for spread via infested soils and potting media, and contaminated water. Additionally, timber, firewood, and woodchips stored under moist conditions can serve as long-distance vectors of the pathogen. Long-distance spread resulting from shipment of infected nursery stock is precisely the situation Connecticut is facing due to the transport of infected nursery stock from the West Coast.

Local spread of *P. ramorum* commonly occurs from movement of infected plant material, rain and irrigation water, and human activities (e.g., handling plants in nurseries, soil in shoes and tires of hikers and bikers, respectively).

One important and classic component of the epidemiology (study of the way diseases spread) of *P. ramorum* is the role played by different hosts. This component presents a "conundrum" since hosts exhibiting "Sudden Oak Death"-type symptoms, which are often killed, usually aren't good sporulation hosts for *P. ramorum*. Whereas, hosts exhibiting "Ramorum Blight"-type symptoms aren't usually killed, but are extremely good sporulation hosts for *P. ramorum*. These latter hosts are considered the epidemiologically important hosts in the spread of this disease since they are not killed by the infection and serve as a continuing source of the pathogen. Spores produced on the Ramorum Blight hosts are believed to infect and cause the killing cankers associated with SOD.

Although infections in natural and nursery situations have been subjected to federal regulations and quarantines and aggressive slash, burn, and spray policies, complete control and eradication has not been achieved. In part, these limitations can be attributed to our incomplete understanding of the life cycle and biology of this formidable pathogen.

WHAT IS HAPPENING IN CONNECTICUT? (Is Connecticut at risk?)

Scientists at CAES have been watching the situation on the West Coast since the first report of the mysterious, tree-killing disease in 2000. Additionally, the regulatory

authority for Connecticut rests with CAES. There was an immediate response to the needs of Connecticut upon learning of shipments of potentially infected stock to the state. A team, informally called the "CT Ramorum Blight (SOD) Team," has been assembled, which includes plant pathologists, state entomologists and plant inspectors from CAES as well as the state plant health director and inspectors from USDA Animal Plant Health Inspection Service- Plant Protection and Quarantine (APHIS-PPQ).

The potential spread of *P. ramorum* from the West Coast to other states was realized at a national level in 2004. The first "red flag" was raised in March 2004, when Connecticut was notified that a nursery had shipped potentially infected camellias from two California locations to approximately 39 states, including Connecticut. Nursery records indicated these shipments occurred as far back as 2003. Trace-forward investigations were immediately conducted. Trace-forward investigations or "trace-forwards" are based on the shipping records of the nursery that sent contaminated plants. They are used to track the path of the suspect plants to new locations, usually nurseries, and assess or test the condition of those plants in these locations. No camellia plants that had been part of the shipments to Connecticut tested positive for *P. ramorum*. The second "red flag" was raised in late October 2004, when Connecticut was notified about shipments of purportedly infected plants from Oregon. Some of these plants (shipped to many states from February-September 2004) were distributed to 56 outlets in Connecticut. The collective total of plants shipped to Connecticut was over 10,000 plants. Trace-forwards were immediately conducted on all of the plants that could still be located. Plants in three outlets tested positive for *P. ramorum.* Since many of the plants in the shipment had been sold as cash and carry, it was not possible to account for all of the infected plants. Thus, it is realistic to assume that some infected plants have been placed in the Connecticut landscape.

In addition to conducting trace-forward surveys, the CT Ramorum Blight Team participated in the National USDA APHIS-PPQ Ramorum Blight survey in 2003 and 2004 and the U.S. Forest Service Perimeter Survey in 2004. No plants in the surveys tested positive for *P. ramorum*. Participation in these surveys is also planned for 2005.

Detection and confirmation of *P. ramorum* is a complex task due to the use of three different testing processes. These procedures are Enzyme-Linked Immunosorbent Assay (ELISA), isolation and culture, and molecular detection using Polymerase Chain Reaction (PCR). ELISA is a serological test used as a prescreen to detect the presence or absence of a *Phytophthora* species in the plant. This test is not specific for *P. ramorum.* If the ELISA test is positive, then ELISA-positive plant tissues are placed on selective culture media. Once the organism is growing in culture, the identity of *P. ramorum* is confirmed by microscopic examination. Because of its unique morphological characteristics, *P. ramorum* is distinguished from other *Phytophthora* species, such as *P. cinnamomi* or *P. cactorum.* The latter two species are commonly found in Connecticut. Culture assays also verify the viability of the organism. Concurrent to culture, DNA extracted from the ELISA-positive samples is used for molecular detection using PCR. This technique confirms the presence of DNA originating from *P. ramorum* (and therefore identifies the organism) on the basis of a

unique profile of DNA.

The detection of *P. ramorum* in plants shipped to Connecticut and likely planted in our landscape raises many concerns and questions, for many of which, we have no science-based answers. Will *P. ramorum* survive and grow in Connecticut? What hosts might contribute to survival and spread in the Connecticut environment? What is the importance of any soil phase in the ecology of the pathogen? How does it survive adverse conditions? Why are so many plant species susceptible to this pathogen? The list goes on. There are many informative web sites, fact sheets, publications, and a hotline on this topic. *Phytophthora ramorum*, the causal agent of Ramorum Blight and SOD, is a serious pathogen, with significant potential for economic and ecosystem disruption. It is important to be concerned and aware of this pathogen since early detection is important for containment and management.

The "Ramorum Blight (SOD) Hotline" is 1-888-703-4457.
Among the helpful websites are:
California Oak Mortality Task Force: http://www.suddenoakdeath.org/
NAPIS: http://ceris.purdue.edu/napis/pests/sod
USDA APHIS PPQ: http://www.aphis.usda.gov/ppq/ispm/pramorum/

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RHIZOSPHAERA NEEDLECAST

This common needlecast disease causes premature death and casting of needles on several conifers in the Connecticut landscape and in Christmas tree plantations. Several species of spruce (*Picea*) are the most common hosts, although Colorado spruce sustains the most damage in the landscape. Rhizosphaera needlecast is an occasional problem on pine (e.g., Austrian, mugo, eastern white), Douglas-fir, and true fir (e.g., noble, silver).

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 fall or the following spring. Diagnostic symptoms may develop in early September but typically occur in spring: infected needles turn a distinctive lavender or purplish-brown. At that time, pinpoint black fruiting bodies of the fungus appear in the stomata of the infected needles. These can be seen with a hand lens and appear as fuzzy black spots instead of white stomates. During periods of rain and wet weather, spores of the fungus are released and are rain-splashed onto newly developing needles where infection occurs. The infection period for this disease can be quite long since infections begin in spring and can continue until autumn. The fungus usually attacks needles on the lower branches first and gradually progresses up the tree. 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 and the fungus overwinters in infected needles on the tree and in fallen needles. Under epidemic conditions, lower branches may be killed by the fungus. In extreme cases, Rhizosphaera needlecast can result in tree death.

Rhizosphaera needlecast is often first evident in sites that are naturally moist or have poor air drainage or are adjacent to taller trees that reduce wind-drying of the foliage. *Rhizosphaera* typically infects newly grown 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.

MANAGEMENT STRATEGIES

Rhizosphaera needlecast is not considered a life-threatening disease; it can be managed through the combined use of culture, sanitation, resistance, and fungicide sprays. Cultural methods include use of healthy stock and maintenance 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. All prunings should be removed from the vicinity of the tree since the fungus can mature on branches that 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 further reduce the spread of disease, pruning should not be done when the foliage is wet.

When possible, it is helpful to use resistant varieties. Colorado and Englemann spruce are most sensitive, white spruce is intermediate, and Norway spruce is 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, 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.

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SLIME MOLDS

Slime molds are highly conspicuous fungi that often seem to "magically" appear on mulch, plants, and turf overnight. The rapid appearance of these nuisance fungi is frequently a cause for misdirected alarm. These fungi have also been the source of countless stories and colorful names such as the "blob" and the "dog vomit fungus."

Slime molds are easily recognized by their brightly-colored structures. The most common slime molds on mulch appear as bright yellow, orange, or creamy tan irregular masses. The size of these masses can range from an inconspicuous inch to a dramatic several feet in diameter. True to their common name, slime molds are somewhat slimy when they first form but gradually dry to a powdery brown or tan. On turf, the most common slime molds appear as bluish gray to purple brown patches that can be as large as several feet in diameter when viewed from a distance. Upon close inspection, individual grass blades are encased by the structure of the fungus. Similar symptoms can develop on woody and herbaceous plants after they have been covered by the superficial growth of the fungus. Although slime molds are not pathogenic to plants, they occasionally cause indirect injury when they cover and shade plant tissues for extended periods of time. Slime molds have no direct economic importance.

Slime molds are fungi in the class Myxomycetes. These are cosmopolitan organisms that feed on bacteria, protozoa, and other tiny organisms. As is the case with other fungi, slime molds reproduce by spores. Once the spores germinate, they go through several developmental stages that eventually result in a feeding stage called a plasmodium. A plasmodium is a multinucleate mass of protoplasm that results from the fusion of amoeba-like cells. This is a "creeping" stage of the fungus so when sufficient water is available, slime molds creep or flow over many types of surfaces. They creep at a fairly fast pace and can actually move several feet in 24 hours. When environmental conditions are no longer favorable for this stage of the fungus, the slime mold forms the more conspicuous and recognizable structure previously described.

The growth of slime molds is favored by 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 fungi, slime molds are often more abundant during or after periods of cool, wet weather, especially in spring and autumn. Slime molds have been more prevalent in

landscape situations during the past 5 years and this appears to be associated with the weather 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, pro-active control is not necessary. However, these fungi 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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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 spiraling down the tree where a 1-4" 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 snow cover
   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 groundcovers (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, honeylocust
   - 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, oedema, 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 to 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 that 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 that 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

III. 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

IV. 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

V. 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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SPHAEROBOLUS STELLATUS - 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 stellatus.* These brown spots, called peridioles or glebal masses, are approximately 2.0 mm (1/12 inch) in diameter and are the dispersal structures of this fungus. *Sphaerobolus* is a Basidiomycete and a member of the Nidulariales. It is a cosmopolitan saprophyte on wood and bark chips, dying and decaying wood, and dung and is not considered a pathogen of herbaceous and woody plants, animals, or humans. The increased prevalence of this fungus during the past five years appears to be partially associated with the increased popularity and use of wood mulches in the landscape.

Sphaerobolus is commonly called the "artillery fungus" or "sphere thrower" since it forcibly ejects the peridiole 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 is influenced by temperature, light, and moisture. When temperatures range between 10°C and 20°C (50°F and 68°F) and moisture levels are adequate, the fungus produces fruiting bodies. These structures usually form on the substrate (bark, dung, or decaying plant material) in autumn and spring and are quite small, approximately 2.5 mm (1/10 inch) in diameter. Because of their size, they are often very difficult to find in the mulch although areas of mulch supporting growth of the fungus may appear matted or gray and somewhat bleached in color. As the fruiting structures mature, they usually remain active or "shoot" for approximately 2-3 weeks. Adequate light and moisture are also necessary for ejection or discharge of the peridiole. Changes in osmotic pressure within the fruiting structures cause them to absorb water and become more turgid. This process creates enough force (1/10,000 horsepower) to propel the glebal masses or peridioles into the air. This ejection process is phototropic so the peridioles are projected towards the light. Peridioles are typically quite sticky and, since they are forcibly ejected, they readily adhere to objects upon which they are impacted. When the peridioles dry, they become *very* difficult to remove. Unfortunately, *Sphaerobolus* can be long-lived and peridioles have been found to still be viable for up to 12 years. Peridioles can also be naturally dispersed by wind or over great distances on plant debris, mulch, animal fur, and even animal dung.

STRATEGIES FOR CONTROL:

Prevention and avoidance are the major strategies for control of this fungus since chemicals are ineffective. 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 of the fungus. Some success has been achieved by periodic overlaying with fresh mulch, thereby reducing the light that is important for peridiole discharge. However, when overlaying, it is important to avoid making the mulch layer too thick. It is also important to select mulches that contain ***at least 85% bark.*** Avoid mulches that contain a high proportion of wood since wood chips are better sources of carbon, an important food source for the fungus, than mulches that mainly contain bark. All types of wood mulches can potentially support the growth of this fungus and research is currently in progress to determine if one type of mulch is more frequently associated with this fungus than another. Another tactic to minimize this problem in the landscape is to use an alternative form of mulch such as black plastic, stone, pea gravel, or marble chips 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 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. Additionally, extensive staining can 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.

Since the brown dots or peridioles of the fungus can remain viable for more than 10 years, they can serve as a means to spread the fungus. As a consequence, care should be taken when scraping them off affected surfaces. The peridioles won't 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.

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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 that distinguishes 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 of these rusts 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***
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 that reduces the marketability of the infected trees.

Symptoms first appear as yellow spots or flecks on needles in late winter and early spring. These spots eventually develop into pustules or blisters (telia) and burst open to reveal masses of yellow-orange spores (teliospores). The teliospores then produce another type of spore (basidiospores), which are readily blown by wind and splashed by rain onto needles of the same tree or onto those of adjacent trees.

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.

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 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 wet (this spring), up to 5 sprays may be necessary;

II. HETEROECIOUS SPRUCE NEEDLE RUSTS

1. **Causal Agent: *Chrysomyxa ledi* and *C. ledicola***
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 midsummer. 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) that are released and carried by the wind to infect newly emerging and developing spruce needles. By midsummer, 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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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 that 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 that 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 that may not harden-off properly for the winter; 4) prune and remove any dead twigs or branches that 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.

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WINTER INJURY ON WOODY ORNAMENTALS

Weather conditions during the past few winters in Connecticut have been conducive for 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 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, 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 groundcovers such as ivy and pachysandra.

SYMPTOMS:

Symptoms of winter injury are quite variable and depend upon 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 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 rhododendron and mountain laurel, the most familiar leaf symptom is characterized by a marginal browning and longitudinal rolling along the mid-vein. 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 that 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.

STRATEGIES FOR CONTROL:

Although the weather can't 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 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;
- have sufficient moisture in the root zone before the soil freezes--this can be accomplished by giving the shrubs (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--this stimulates and encourages growth late in the season that may not harden-off properly for the winter;
- prune and remove any dead twigs or branches that 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.

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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 waterlogged 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 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. 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 (arborvitae) 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 that 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 <u>any</u> 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 minimized by following a regular pruning and general care program throughout the life of the plant.

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