SPRUCE DISEASES & PESTS SUMMARY

See attached information for more detail about each disease or insect.

DISEASE OR INSECT	SYMPTOMS & ID	LIFE CYCLE	CONTROL
***Cytospora* Canker** (fungus) Most susceptible trees: Colorado blue & Norway spruce Somewhat susceptible: Douglas fir, hemlock, larch Rarely affects trees less than 15 – 20 yrs. old.	Starts on lower branches and progresses upward. Needles have purplish hue, turn brown and drop. Fungus can enter trunk through wounds killing the cambium layer and leaves dead bark—called canker. White resin or "pitch" covers the cankers and may flow down trunk. Canker development most severe in trees under stress (drought, insect damage, crowding, mechanical damage. Symptom development becomes more common 1-2 years following severe drought.	Fungus survives in diseased stems, grows slowly, eventually circling and killing a twig or branch. Spores are the principal means disease spreads to other branches by rain, wind, sprinklers, pruning tools or movement of insects and birds. Infections occur in cool, wet weather.	Cultural: Plant new trees and avoid crowding; plant Norway or white spruce; do not injure root system; water well in dry periods; remove infected branches and avoid working when branches are wet; clean and disinfect tools. Chemical: None. Fungicides are generally not effective.
***Phomopsis occulta* canker** (fungus) Most susceptible trees: Colorado blue, white spruce Also susceptible: Black hills, Norway and Siberian spruce Other spruce species may be hosts for the fungus.	Needle discoloration, turning brown or purple and falling off branches (similar to Rhizophaera). Most dramatic symptoms occur in spring as new shoots expand, then rapidly wilt and die, tips curling. Stem infection is small purplish lesions below the bark. May cause no symptoms until 3-4 wks. after stress.	Spores emerge during wet spring & summer weather and spread by rain splash. There is difficulty in distinguishing Phomopsis from other canker and needlecast diseases. Most prevalent in nursery plantings, but has become more pronounced in existing, mature trees.	Cultural: Remove affected stems during dry weather, sterilize tools with bleach between cuts; remove severely diseased trees including stump; burn or bury affected branches as soon as possible. Chemical: Benzamidole fungicides can be effective.
***Rhizosphaera kalkhoffii* needle cast** (fungus) Most susceptible trees: Colorado blue spruce Other hose trees: White and other spruces Austrian, mugo, red, white pines Douglas fir Resistant trees: Norway spruce relatively resistant	Second yr. needles turn purple to brown and fall off tree. After several years of needle loss branches may die. Generally appears to die from bottom up, but infections may start higher on tree giving the appearance of scattered dead areas. Small black spots appear in rows in infected needles.	Fungus over winters in infected needles on tree and those that have fallen to the ground. It is spread by splashing and dripping water in spring through fall. Newly emerged needles can become infected during wet spring weather. During late summer, first year needles appear mottled or speckled with dull yellow or reddish blotches. Later, often the next year, infected needles on interior of branches turn purplish-brown and drop. Trees are rarely killed, but several years will take its toll.	Cultural: Avoid working near trees in wet weather during the growing season; remove dead branches, fallen needles and cones under the trees; prune surrounding plants to promote better air circulation; water well in dry periods; space new trees adequately to promote good air circulation; do not shear trees when foliage is wet. Chemical: Copper-based fungicides (Bordeaux or Mancozeb) are effective as a preventive control on unaffected foliage. Begin applications when new needles are half-grown and again when fully expanded, about 3 wks. later. Shorten interval if rainy weather occurs. Treatment cannot "cure" existing infections.

DISEASE OR INSECT	SYMPTOMS & ID	LIFE CYCLE	CONTROL
Setomelanomma holmii (fungus)	Sudden needle drop. MAY OR MAY NOT be related to this disease.		
Stigmina lautii (fungus)	GrowS in the needles and stems. Similar to Rhizosphaera, but difficult to ID.		
Spruce Gall Aphids (insect) Eastern spruce gall: primarily attacks Norway and white spruce. Cooley spruce gall: Primarily infests Colorado blue spruce (& other spruces), Douglas fir	Cone or pineapple-like galls on developing twigs which deform, stunt and girdle twig. Heavy and repeated infestations will seriously disfigure and weaken trees, rendering them susceptible to other diseases and insects. Cooley Galls are elongated, 1-3" in size.	Eastern: aphids overwinter in bark crevices. In early spring, they mature and adults lay eggs under waxy cover of twigs. Eggs hatch about the same time as new growth begins and nymphs feed near base of buds, causing formation of a gall. Nymphs feed and develop within the galls. In late Aug.-Sept. galls open and nymphs appear becoming winged adults which fly to nearby susceptible trees where they deposit eggs which soon hatch and give rise to over-wintering nymphs. Cooley: Similar to Eastern with some differences associated with infestation of Douglas fir.	Cultural: Remove and destroy green galls to reduce aphid population—removing brown galls will have no benefit. Chemical: Early-spring application of dormant oil will effectively control overwintering nymphs and prevent gall formation. Note: oil application to blue spruce may cause loss of blue color. Apply a contact insecticide at bud break will control immature nymphs. Fall application of contact insecticide in late Sept. to early Oct. will eliminate over-wintering nymphs. Fall treatment is preferred since timing is less critical and weather conditions may be more conducive to spraying.
Spruce Spider Mite (insect) Common on fir and spruce species and Douglas fir.	Needles have a speckled appearance, increasing until foliage appears bronze or bleached, and may cause needle drop. Webbing surrounding needles and twigs often accompany high populations.	Red eggs found on the bark or small branches over-winter. In spring eggs hatch as early as mid-March through mid-April. Young mites feed on previous year's foliage and do not attack new growth until it hardens off in summer. Mites to best in daytime temps. of 60's-70's. When daytime temps. Exceed mid-80's adults become inactive and populations decline. If temps. remain over 90 for an extended period, adults lay tan or salmon colored eggs that hatch when cooler temps. in late summer-fall return. Adult mite feeding activity resumes and continues until late fall. Adult females lay eggs on the bark of small branches in early Sept. through hard frost.	Biological: Naturally occurring predators can keep populations in check. Mechanical: Mites can be dislodged during heavy rains or spraying plants with a steady, forceful jet of water twice a week during periods of peak mite activity. Cultural: Provide adequate water during dry periods to reduce stress. Chemical: Use insecticidal soaps or horticultural oils. Note: these materials may remove the blue color from Colorado blue spruce needles and cultivars.

SPRUCE PROBLEMS ARE PROBABLY CAUSED BY MORE THAN A SINGLE AGENT

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A recent news article circulating through various media outlets suggests a link between spruce dieback and the use of a new DuPont herbicide Imprelis. This injury may overshadow a more serious decline of spruce that we have been working on for the past few years. In monitoring spruce, we have observed a significant decline in health beginning approximately five years ago, which is now manifesting itself as a severe and even devastating problem throughout Michigan's Lower Peninsula. Symptoms include loss of interior needles, increased twig and branch dieback, decreased growth and, in some cases, death of the tree.

Just walk outside your home, place of business or shopping center, and you can find landscaped spruce that are healthy, severely impacted or just beginning to show symptoms, if you know what to look for (Photos 1-8). These symptoms do not correspond to the use of Imprelis but instead correspond with two new fungal infections of spruce first observed in Michigan during the past 10 years.

These fungi, *Setomelanomma* and *Stigmina* (see additional below) grow within the stem and needle tissues of spruce, respectively. *Stigmina* is found infecting the needles of spruce where it may or may not be a needlecasting pathogen. It was first observed in 2003, roughly about the same time it was observed on spruce in other states. It appeared to come down from Canada in the 1990s.

A well-known and common needlecasting pathogen of spruce is *Rhizosphaera* (see additional below). This pathogen can become epidemic at tree farms and cause serious needlecasting problems, hence management programs have been described here and other locations for several years. So now we can find *Rhizosphaera* and *Stigmina* growing in the needles of spruce.

Setomelanomma holmii was first thought to be a pathogen but now is not considered a pathogen and can often be found growing and reproducing in the stems of apparently healthy spruce trees, as do well known fungal pathogens of spruce such as *Phomopsis* and *Cytospora* (see additional below). Both *Phomopsis* and *Cytospora* are common fungal pathogens of spruce producing branch cankers that can kill foliage and branches—stem cankers can eventually kill trees. So now we can find *Phomopsis*, *Cytospora* and *Setomelanomma* growing in stems of spruce.

It is obvious that the three stem-infecting fungi can interact with each other and the two needle-infecting fungi can interact with each other. What may not be as obvious is the potential interaction between the needle infecting fungi and the stem infecting fungi. As we look for clues as to what may have changed for spruce cultivation in the past ten years, to us, these fungal interactions, as well as the climate, loom high on the list of potential factors.

Today we are witnessing the branches of spruce trees–Colorado blue, white (Black Hills), and Norway–drop needles and die. Is this due to one of these pathogens, the interaction of all of these fungi, or the interaction of more than one pathogen or fungal infection? Many of the dying branches are infected with *Phomopsis*. However, *Phomopsis* is normally a stress pathogen causing light, moderate or at times severe infection depending on weather, planting density, age of tree (worse on young trees in nurseries), and overall health of the tree.

Why are we finding so much *Phomopsis* on older trees? Could it be due to additional stresses caused by the new spruce infecting fungi, such as the non-pathogen *Setomelanomma* or *Stigmina,* which has not officially been proven a pathogen on spruce, yet? Or can it be blamed on the weather? Often there is too much rain in the spring and it is too dry in the summer. Or have we planted spruce on poor sites?

SEE ALSO: The article below, "Spruce Declining Rapidly Around Michigan", by the same authors.

July, 2011 by Dennis W. Fulbright, Mursel Catal, Sara Stadt and Jill O'Donnell
Michigan State University Extension, Department of Plant Pathology

Photo 1. Mature landscape trees showing varying amounts of spruce decline. If you look at the base of the healthy tree on the right, you can begin to see branch death.

Photo 2. The first noticeable symptoms are browning of last year's needles and the death of some small branches.

Photo 3. On some trees, you may be able to see typical Phomopsis *infection symptoms where new growth curls downward and dies.*

Photo 4. Continued Phomopsis *infection will lead to the death of branches.* Phomopsis *isusually considered a stress pathogen.*

Photo 5. The needlecasting pathogen Rhizosphaera *is producing fruiting on a spruce needle that will soon cast.*

Photo 6. This needle appears to show signs of both Rhizosphaera *and* Stigmina *fruit bodies. DNA analysis will not only verify this, but also tell us which fungus is more predominant.*

Photo 7. Spruce needles with varying degrees of infection by *Stigmina* and perhaps *Rhizosphaera* may be present, too.

Photo 8. Spruce needles and stem infected by and showing signs of Stigmina *and* Setomelanomma*, respectively, two relatively new fungal species found on spruce in Michigan.*

Spruce Declining Rapidly Around Michigan

By Dennis W. Fulbright, Mursel Catal, Sara Stadt and Jill O'Donnell

Last fall we were asked to take some time to visit a tree farm in central Michigan and take a look at their blue spruce planting which was experiencing what we thought at the time was a unique problem. We were told the trees had been diagnosed with Phomopsis canker and the owner wanted to know where the disease came from, why it was so severe on his trees, and what he could do about it.

Fig 1: Spruce with die back around skirt.

Fig 2: White spruce with dead branches from bottom to top.

After a trip to the tree farm, we saw at first what appeared to be extremely healthy spruce trees with some die back around the skirt of the trees rising up two or three whirls of branches in some cases (Figure 1). He had already culled many trees. It certainly could have been caused by Phomopsis canker based on the symptoms, and since the MSU Diagnostic Laboratory had already nailed down the pathogen we began to focus on the three major questions confronting the grower: Where did it come from? Why is it so severe? And, what can be done?

A lot has transpired between that fall day last year and this past summer. More calls came in regarding this problem at other tree farms as well as in the landscape (Figure 2). Was it becoming more widespread? While we still don't know why Phomopsis canker started infecting trees around the state, we have now confirmed that Phomopsis canker is wide spread on all ages and species of spruce trees in Michigan and is causing major dieback and even death to landscape spruce trees. But it isn't only cankers caused by Phomopsis causing branch death and needle loss, although *Phomopsis* appears at this point the most frequent cause. We are finding cankers initiated by other common fungal pathogens.

We are beginning to think that we are going to need a program or playbill in order to tell all of the players and cast of characters apart. We now know that *Phomopsis* is probably the star of the show, but we also know that *Cytospora* and *Diplodia* (formerly *Sphaeropsis*) can be found on dead and dying spruce branches around the state. We also know that two needlecasting problems, one caused by

Fig 3: Spruce showing symptoms of decline.

Fig 4: Typical Phomopsis symptoms on spruce.

Rhizosphaera and the newly invasive fungus that grows on the needles called *Stigmina* are also involved. We also know that, again like any good story or play, the characters are not who they first seem to be. Thanks to DNA analysis, we have found that the new fungus we have been calling *Stigmina* for the past several years is probably another species and is more closely related to the species of fungi causing brown spot needlecast of Scotch pine or Swiss needlecast of Douglas fir. We are also wondering if *Phomopsis* itself is the same *Phomopsis* we have seen before, or if it has changed and become more aggressive.

Just as we were making some progress on this dieback disease of spruce, a news article began circulating through various media sources suggesting a link between spruce dieback and the use of a new DuPont herbicide Imprelis®. How are landowners going to separate this widespread Phomopsis canker problem from this reported herbicide injury? We were afraid this new herbicide injury would overshadow the more widespread serious decline of spruce occurring throughout Michigan. Therefore, we began a series of articles on on the MSU Extension news website.

Today we are witnessing the branches of spruce trees – Colorado blue, Englemann, white (inlcuidng Black Hills), and Norway – drop needles and die (Figure 3). Is this due to just one of these pathogens, the interaction of all of these fungi, or the interaction of more than one pathogen or fungal infection? *Phomopsis* normally requires stress events for infection, but now we are finding it all trees throughout the state even in what one might consider good sites. Could the stress be brought on by weather, the amount of inoculum (spores), or other diseases?

Thanks to MSU Project GREEEN funds (Generating Research and Extension to meet Economic and Environmental Needs) received this year, we now know that many of the dying branches are infected with *Phomopsis*. However, *Phomopsis* is normally a stress pathogen causing light, moderate or sometimes severe infection depending on weather, planting density, age of tree (worse on young trees in nurseries), and overall health of the tree. Why are we finding so much *Phomopsis* and on trees of all ages including older landscape trees? Could it be due to additional stresses caused by the new spruce infecting fungi, such as the occurrence of *Stigmina*, which has not officially been proven to be a pathogen on spruce, yet? Or can it be blamed on the weather? We know there has been too much rain in the spring and often times too dry or too wet in the summer. Could it be there are just too many spruce trees in the landscape and it is building up inoculm like a monoculture tree farm?

One thing is certain: It is getting worse and it can be found throughout the state. There are still plenty of healthy spruce trees, but mixed among them are spruce trees declining in front of us. Using Project GREEEN funds, we have developed DNA

Fig 5: Symptoms can be found progressing toward the crown of the tree.

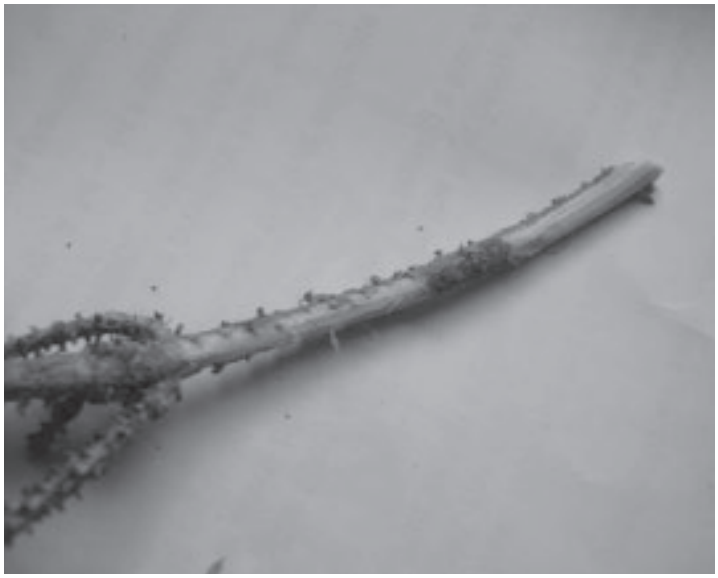

Fig 6: Canker on small branch needs to be taken back to the laboratory to determine which pathogen is causing the infection. It could be Phomopsis, Cytospora or Diplodia. Until cultured it is difficult to say and it could be anyone of these. So far, the odds are that it is Phomoposis. The infection is already killing the branch.

markers to detect the fungi, find which pathogens are present and which pathogens are required for symptom expression and tree death. We will begin management studies once we know what pathogens need to be managed.

Symptoms generally start in *Phomopsis* fashion, at the bottom of the tree, killing current year growth. The dead branch tips turn downward (Figure 4). These branches will die. What appears to be unusual, and gives us thoughts that other pathogens may be involved is that only needlecasting can take place on other branches and the last tissue of the branch to die is the terminal bud. The symptoms appear to follow a needlecast-like progression being found where moisture stays the longest on the tree including the base of the tree where branching is thickest and rain and dew remain the longest. Other locations for infection include the north side of the trees, for the same reasoning as above. In that sense, it appears that spores requiring free moisture for infection and disease expression. But it does not stop there.

Perhaps the most surprising situation is that the symptoms (dead branches) continue to progress toward the top of the tree (Figure 5). Generally, the crown is the area where needles and branches dry the fastest and therefore, much less disease is found near the crown. However, we have been able to find *Phomopsis* from the lower branches to the top of the tree. We have also been able to find *Diplodia* and *Cytospora* infections, too (Figure 6). At this point, we cannot walk up to a tree with branch death and determine by observation, which pathogen is present—we must take samples back to the lab. This makes it troublesome for treatment as both *Phomopsis* and *Diplodia* can normally be managed by chemical application, but *Cytospora* has recalcitrant to chemical application. This is not saying that this new decline is manageable at all.

The symptoms appear to follow a needlecast-like progression being found where moisture stays the longest on the tree including the base of the tree where branching is thickest and rain and dew remain the longest. Other locations for infection include the north side of the trees, for the same reasoning as above.

At this early stage only time will tell. There is only one thing we can say with some certainty—there are going to be a lot of disappointed people when they see their spruce trees next year.

CYTOSPORA CANKER

Cytospora canker, caused by the fungus *Cytospora kunzei* (also known as *Valsa kunzei* var. *piceae*), is the most prevalent and destructive fungal disease of Colorado blue spruce and Norway spruce. Occasionally, Cytospora canker is found on Douglas-fir, hemlock, and larch. Susceptibility varies widely among species, but generally trees under stress or growing outside their natural range are more prone to the disease. Cytospora canker rarely affects trees less than 15 to 20 years old. Infected trees are weakened substantially, but are rarely killed. However, they can be severely deformed, often making them unsuitable for the landscape.

Symptoms & Identification

The disease normally starts on the lowest branches of the tree and, over a period of several years, progresses upward. At first, needles have a purplish hue, eventually turning brown and dropping, leaving dry, dead, brittle twigs and branches.

On severely infected trees, the fungus will enter the trunk through wounds (usually where the branch meets the trunk of the tree), killing the cambium layer and leaving dead bark. This dead tissue is called a "canker."

A conspicuous white resin or "pitch" covers the cankered portion of the branch or trunk, sometimes flowing several feet down the trunk of the tree. This is an important means of diagnosing Cytospora canker; however, resin flow can also be associated with other tree injuries and is not exclusively symptomatic of of Cytospora canker. Within the cankered area, black, pinhead-size fruiting structures (pycnidia) of the fungus can be seen with a microscope or hand lens and are a positive sign of the disease.

Disease Cycle

The fungus survives long-term as mycelium and spores in diseased stems. The canker grows slowly, eventually circling and killing a twig or branch. The fungal spores (conidia) are the principal means by which the disease spreads to other branches, entering through bark wounds and injuries. Infections occur in cool, wet weather. Spores are dispersed by splashing rain, wind, sprinklers, pruning tools, and possibly by movement of insects and birds.

Canker development is most severe in trees under stress from drought, insect damage, crowding, nutrient imbalance, and mechanical damage to branches, trunks, or roots. Symptom development becomes more common one or two years following a severe summer drought.

Control: Cultural

Because Cytospora canker is a stress-induced disease:

- Plant new trees in sites that are favorable to their growth (e.g., avoiding places where they become too crowded).
- Plant Norway or white spruce instead of Colorado blue spruce if your site is not favorable.
- Minimize stress to established trees by taking care not to injure the root system or compacting the surrounding soil. Use a 3-4 inch layer of organic mulch to retain moisture and reduce rapid soil temperature fluctuations.
- Water trees well in dry periods and provide adequate moisture in late fall before the ground freezes.
- Infected branches should be removed to improve appearance and reduce chances of further spread. Avoid pruning or working around trees when foliage, twigs, and branches are wet because water disperses the fungal spores. It may take two or more consecutive seasons of pruning to significantly reduce the disease.
- Clean tools thoroughly and disinfect with rubbing alcohol, a 10% bleach solution or comparable disinfectant after each cut when pruning out diseased wood.

Control: Chemical

Applications of copper-containing fungicides have not been effective in preventing or treating Cytospora canker and, in general, chemical control is not useful in controlling this disease. Fungicide sprays are generally not effective at controlling canker diseases.

RHIZOSPHAERA NEEDLE CAST

Rhizosphaera needle cast is a common foliar disease of spruces and other conifers caused by the fungus *Rhizosphaera kalkhoffii*. Colorado blue spruce is particularly susceptible and can be severly damaged by this disease. Other hosts include white, black, Engelmann, Sitka, and Serbian spruce; Austrian, mugo, Eastern white, and Japanese red and black pine, as well as Douglas-fir and Siberian fir. Norway spruce is relatively resistant.

Symptoms & Identification

The disease is usually first evident on lower branches and then works upward gradually. Second-year needles turn a purple or brown color and eventually fall from the tree.

After several successive years of needle loss branches may die. In general, trees appear to die from the bottom upward. In some cases, however, infections start higher on the tree, giving the appearance of scattered dead areas.

The disease can be diagnosed by looking at the discolored needles with a magnifying glass or hand lens. Small black spots (fruiting structures of the fungus) appear in rows in the infected needles. The fungus is actually emerging from the stomata (natural pore-like openings) that occur in lines on all sides of a spruce needle. Healthy stomata appear white. The rows of black stomata are a diagnostic feature of Rhizosphaera needle cast. Green needles may also show these small black fruiting structures.

Disease Cycle

Rhizosphaera over winters in infected needles on the tree and on needles that have fallen to the ground. The fungus is spread by splashing and dripping water beginning in spring and continuing into the fall. Newly emerging needles can become infected during wet spring weather.

During late summer, this disease causes first year needles to appear mottled or speckled with dull yellow or reddish blotches. Later, (often the next year) infected needles on the interior of a branch turn purplish-brown (from the tips downward) and drop prematurely. Infection generally begins in spring on the needles of the lower branches soon after the needles have elongated. Symptoms spread upward and around the tree.

Sometimes infection will start on branches in the middle of a tree, creating defoliation “holes” among healthy branches. Heavily infected trees can suffer severe needle loss and branches may die as they become defoliated. Trees are rarely killed by Rhizosphaera needle cast, but several years of attack will take its toll and only the current season needles may remain.

In moist conditions, the fungus inside older needles produces black fruiting structures (pycnidia) that appear as distinct rows of black, pinhead-size dots. These fruiting structures emerge through needle pores (stomata), either before or after the needles have dropped. This disease can be frustrating because severe defoliation can occur quite rapidly and without indication that the disease is even present.

Control: Cultural

As with most fungal diseases, infection occurs in warm, wet weather. The spores of Rhizosphaera needle cast are released from spring until fall; thus, working near trees in wet weather should be avoided throughout the growing season.

For trees showing symptoms:

- Remove (when feasible) dead branches, fallen needles, and cones under the tree to prevent further infections.
- Prune surrounding plants to promote better air circulation.
- Keep plants well watered, especially in periods of drought, to alleviate stress. Water all evergreens before winter to avoid root desiccation and winter injury.
- Space new trees adequately to promote good air circulation.
- Do not shear trees when the foliage is wet.

Control: Chemical

Copper-based fungicides, such as Bordeaux or Mancozeb, are currently registered and effective as a preventive control against this disease. Begin applications when new needles are half-grown and again when needles are fully expanded, about three weeks later. If rainy weather occurs, shorten the spray interval. Treatments can only protect uninfected foliage. They cannot "cure" existing infections.

Use pesticides safely and wisely; read and follow label directions on containers for dilution rates and methods of application. The user is responsible for determining that the intended use is consistent with the label of the product being used.

Related Fungus

A related fungus that has similar characteristics as Rhizosphaera is the fungus *Stigmina lautii.* Sometimes the black fruiting bodies on symptomatic trees are not the fungus Rhizosphaera, though. Upon closer examination, diagnosticians in other states have found that sometimes the black dots are structures of a different fungus, *Stigmina lautii*.

Under very high magnification, the Stigmina spore-producing structures appear hairy or feathery, while those of Rhizosphaera are smooth and spherical. Most magnifying glasses are not strong enough to see the difference. The spores of the two fungi also appear very different when examined under a compound microscope.

Stigmina is found on needles of trees showing symptoms very similar to those caused by Rhizosphaera needle cast (purpling and loss of older needles, working from the bottom of the tree to top).

Sources: Iowa State University Extension and The Morton Arboretum, Lisle IL

Phomopsis Canker *of* Spruce

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Extension Bulletin E-2417
Cooperative Extension Service
Michigan State University

by
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Spruce cankers may be caused by the fungus *Phomopsis occulta*, and may severely damage the aesthetic value of spruce or in severe cases even kill affected trees. Colorado blue spruce (*Picea pungens glauca*) and white spruce (*Picea glauca*) are most susceptible, but Black Hills spruce (*P. glauca* 'Densata'), Norway spruce (*P. abies*), and Siberian spruce (*P. obovata*) can also be affected. Other spruce species may be hosts to this fungus.

Symptoms

The intitial symptom of *Phomopsis* infection is a barely discernable chlorotic flecking of the needles.

Figure 1.
Colorado blue spruce (*Picea pungens glauca*) seedlings one month after inoculation with *P. occulta*.

Figure 2.
Phomopsis cankers are visible when outer bark is removed.

The discoloration is very subtle and may be difficult to distinguish from mite injury. Infection of the stems results in very small purplish lesions below the bark. These lesions are not visible in an intact branch and may cause no symptoms. The latent infections do not develop until the tree is stressed in some way, as under conditions of drought, flood, transplanting, or other root injury. Under such conditions symptoms develop in a period of three to four weeks.

In seedlings, the terminal leader and all other branch tips may be affected (*fig 1*). This disease has the potential to be devastating in nursery seedling production. In larger plants, the bottom whorls of branches are most affected. Cankers expanding under the bark remain inconspicuous, with no visible depression on the stem. A resinous exudate is often present on the stem in the area of the canker. Cankers are easily seen in infected branches by shaving the bark away with a knife (*fig 2*). Needles on infected branches may turn brown or purple then drop, leaving the twig bare. The most dramatic symptoms occur in spring as new shoots expand, then rapidly wilt and die. The wilted tips curl and often turn a char-

Figure 3.
Symptoms of Phomopsis infection on a white spruce (*P. glauca*).

acteristic pink before turning brown and shedding needles (*fig 3*). Girdling cankers can develop on plants which are heavily infected or severely stressed, leading to the death of the tree. The damage is usually not fatal but can destroy the aesthetic value of the plant for use as an ornamental or Christmas tree (fig 3).

Fungal root rots, soil nematodes, and other cultural and environmental stresses likely predispose plants to *Phomopsis* infection. Due to the difficulty in distinguishing Phomopsis from other canker and needlecast diseases of spruce, submit samples of affected branches to a diagnostic service for positive identification of the fungus before beginning control measures.

Cultural Control

Spores (conidia) of *Phomopsis* ooze from fruiting bodies (*pycnidia*) during wet weather in spring and summer. Rain splash spreads them to infect nearby needles and stems. Blighted stems do not recover and should be promptly removed. Prune during dry weather. Sterilize tools with bleach between each cut to avoid spreading the conidia. Remove severely diseased plants, including the stump. Burn or bury affected branches and trees as soon as possible. Also remove all dead conifers in the area, as this fungus can live and produce spores as a saprophyte on many conifer species. Establishing new spruce plantations in fields which have been fallowed or used for a non-coniferous crop for 2-3 years before planting is advisable. P. occulta may persist in fields after rotation, but the level of inoculum is reduced, decreasing disease pressure on young trees.

Cultural management of plant vigor can help reduce damage caused by plant pathogens, because wounds, water stress and the presence of other pests play important roles in plant susceptibility to infection and disease development. Pruning practices can affect the number and severity of infections. *Phomopsis* mycelia growing on the surface of the plant can enter wounded needles and stems, colonizing the tissue and causing infection. Prune only for shaping and removing damaged branches. Prevent root injury and water stress to help reduce or prevent symptom development. Water ornamental spruce during periods of dry weather and after transplanting to maintain tree vigor. Cultural controls should provide adequate control of *Phomopsis* in landscape situations if healthy planting stock is used.

Chemical Control

Because research shows that cultural strategies alone generally do not satisfactorily control Phomopsis in spruce production, chemical control measures are needed to prevent production losses. Fungicidal suppression of *Phomopsis* occulta will be improved by using combinations of several appropriate fungicides and proper timing. The benzamidoles, such as benomyl, provided the best control of *Phomopsis* in the laboratory. Because Benlate is no longer registered for use on ornamentals, use other benzamidole fungicides such as Cleary's 3336, Fungo 85 and FL, and Topsin M. Other fungicides that have provided good control of P. occulta in the laboratory include Daconil 2782, and Manzate 200. Read the product label to be certain the fungicide you choose bears a current registration for spruce or woody ornamentals.

Apply fungicides to protect spruce during periods of maximum susceptibility. These conditions occur when the inoculum level is high and the host plant is at a venerable stage of growth. The optimum conditions for infection and colonization include warm, humid weather and a tree with tender new growth. Incipient infections may also form during less ideal conditions, but protecting the plant during peak susceptibility should provide adequate control. Fungicide sprays should be timed to protect the new growth from conidia penetration and to suppress the development of existing infection sites when the plants are most susceptible. A series of applications of protectant fungicides should start at the first indication of bud break and continue at approximate 3-week intervals until the new shoots are fully developed and hardened off, (about 8-10 weeks after bud break). An efficient fungicide program, applied as a part of a comprehensive management strategy which includes careful cultural management, should provide good control.

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Phomopsis Spruce Decline

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Figure 1. A 40-year-old Colorado blue spruce with the symptoms of Phomopsis spruce decline, which includes loss of needles and death of branches. The symptoms started on the lower portions of the tree and have worked their way up the tree.

What is happening to our spruce trees? It appears that many of the spruce have, in near synchrony, begun to lose needles and branches from the bottom up (Figure 1). Depending on to whom you speak, some may call this needlecast, some may call it shoot blight (Figure 2) and still others may call it a canker disease. The reality is that they all may be right and they may all be wrong. Since spruce trees already have a common needlecast disease caused by *Rhizosphaera*, there is a good possibility that *Rhizosphaera* is on the needles of the trees and causing needle loss. Since there are at least two, maybe more, common shoot blights of spruce caused by *Diplodia* and *Phomopsis*, the shoot death that we are seeing could be caused by one or the other or both fungal pathogens. And, the branch death — could that be caused by the common canker disease of spruce called *Cytospora* canker? Yes, that is possible and even probable. We could end this article here by saying that some common diseases of spruce are intensifying due to unknown reasons, probably due to environmental circumstances, and spruce trees are dying or being taken down as the outcome. We could say that and be done with it. But, we don't believe that is the entire story.

Figure 2. Phomopsis shoot (tip) blight of Colorado blue spruce observed in Wisconsin and Michigan nurseries and tree farms.

With the scenario described above, we are leaving out something that could be a major part of the story. It was during the time that our laboratory was studying a new fungus growing on the needles of spruce (we thought that fungus might be the cause of the spruce tree problem), we noticed that the branches on spruce trees in nurseries, on tree farms, and in the landscape had several cankers under the thin bark. These cankers were not associated with the known fungal pathogen *Cytospora*, but instead the fungus *Phomopsis*. These cankers could be quite numerous on trees that had been in place 35 to 40 years or more. The cankers were very difficult to see as the external bark gave few clues as to the location and presence of the cankers below the bark. In a few cases, these cankers wept sap, which is usually diagnostic for *Cytospora*. The leaking sap helped us find the cankers under the bark, which proved to be *Phomopsis*. Sometimes we even found *Cytospora* associated with cankers, but most of the time, we have found *Phomopsis*. Based on our DNA work, the *Phomopsis* found on nursery seedlings can be the same *Phomopsis* that is found in the cankers on mature landscape trees.

At the minimum, the *Phomopsis* cankers are adding another degree of difficulty to the survival of the spruce trees; and at the other end of the spectrum, the *Phomopsis* cankers are trumping all other spruce diseases and are slowly killing the trees. But, we are getting ahead of ourselves. We have not proven that this *Phomopsis* even has the power to cause the cankers on these older mature trees. So far, it has been guilt by association, and there has been a lot of association.

Currently, it appears that Engelmann spruce (*P. engelmannii*), Colorado blue spruce (*Picea pungens*), White spruce (*P. glauca*), and Norway spruce (*P. abies*) are ranked,

respectively, from most affected to least affected. However, we have isolated *Phomopsis* from branch cankers found on diseased branches on all of these tree species in various locations in Michigan. It is clear that Colorado blue and Engelmann spruce are the most susceptible, but all of these species are suffering branch death and *Phomopsis* has been isolated from all of these species.

What's new about *Phomopsis*? *Phomopsis* has been a rare visitor to the nurseries and tree farms in the state. The first major outbreaks were shoot blights (Figure 3) in Wisconsin in the 1980s and a decade later it was found in nurseries and trees farms in Michigan. In both cases, it was declared a different species than the one that our laboratory has been finding. To be fair, current DNA analyses take much of the guesswork out of identifying pathogens. Both Wisconsin and Michigan State University research laboratories used the best methods at the time to determine the species. Our laboratory simply sequences portions of the DNA to make comparisons based on the sequences of other species placed in the database. We are simply saying that the DNA sequences do not match up with their species determination, indicating they may have found a different species than the ones we are finding. If it is a new species, then we have a better case to make in saying this new *Phomopsis* is causing a new branch canker on mature and young spruce trees. But, if it does end up being the same, we need to rationalize how this disease of the spruce nursery and tree farm has moved out to the landscape and begun to cause infections of branches leading to unsightly landscape spruce trees.

Figure 3. A much younger blue spruce than in Figure 1, located in Allendale with symptoms of thinning needles and some branch death. Lower branches were detached and taken back to the laboratory for diagnosis.

Symptoms generally start at the bottom of the tree, where branches thin and needles drop (Figure 3). Shoot tips can become infected if the typical shoot blight symptoms are initiated (Figure 4). Ultimately, these branches will die due to cankers that form along the branches (Figure 5). The symptoms appear to follow a needlecast-like progression being found where moisture stays the longest on the tree including the base of the tree where branching is thickest and rain and dew remain the longest. But, it does not stop there. The symptoms (dead branches) continue to progress toward the top of the tree (Figure 1). Generally, the crown is the area where needles and branches dry the fastest and therefore, much less disease is found near the crown. However, we have been able to find *Phomopsis* from the lower branches to the top of the tree.

There is another common symptom and that is when the branches appear to become straight and rigid and most of the interior needles turn brown or purple and begin to drop off of the tree. The tips of the branches may be bright blue (if a Colorado blue spruce) and that contrasts with the darker needles of the second and third year needles in the interior. This symptom may be found on most of the tree from the bottom to near the top of the tree. In the late winter and early spring the needles on some trees fell on the top of the late March snow, well before most needlecast infected needles would detach and cast. In most cases, a tree can appear healthy and within two years begin to show dramatic symptoms.

Koch's postulates is the name of the scientific test that plant pathologists use to determine if a microorganism can actually cause disease. We have tested a few of our strains and found

Figure 4. Phomopsis shoot blight can be found on the terminal end of the branches from the tree in Figure 2, indicating that *Phomopsis* can be found as a shoot blight on the trees in the landscape.

Figure 5. Typical canker on branch of spruce tree observed in Figure 2. The bark was removed until the canker was discovered. Then, tissue on the edge of the canker was cleaned and sterilized and placed on culture medium. *Phomopsis* was cultured from this canker and others on the branches of the tree in Figure 2. The branch still shows some vigor, but as the canker enlarges, the vigor of the branch will probably decrease.

that some could cause disease on young seedling trees in the greenhouse, but we have not tried to determine if the *Phomopsis* strains isolated from cankers on mature trees can cause cankers on large mature trees. Therefore, we have not proven that the strains found are in fact the actual cause of branch death or appear because the branches are dying. This is what we are currently working on in the laboratory and greenhouse.

The most commonly used chemical to manage *Phomopsis* shoot blight in the nursery and tree farm is thiophanate methyl. But, this is primarily used to manage the shoot blight. Trying to manage infections under the bark (cankers) will be asking a lot of this material.

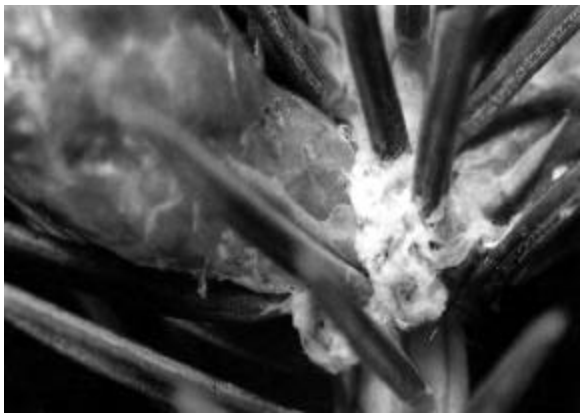
In summary, we have found cankers on the branches of spruce trees that are showing symptoms of needle loss, shoot blight, and branch death. The symptoms continue to accrue and move upward killing branches of the various whorls or scaffolding. Sometimes it is easy to see right through the spruce trees. We have not proven *Phomopsis* to be the pathogen causing symptoms of the large landscape trees, but we have performed Koch's postulates using young greenhouse-grown nursery trees, so we believe the *Phomopsis* strains in our collection are pathogens. We also believe that other fungal pathogens are still present on these trees and that they also may play a role in the disease we are calling Phomopsis Spruce Decline. Most of the spruce trees in Michigan are still very healthy and trees with the symptoms appear to be in the minority.

BARTLETT TREE RESEARCH LABORATORIES
CHARLOTTE, NC
Technical Report

Spruce Gall Aphids

The Eastern spruce gall aphid and the Cooley spruce gall aphid inflict considerable injury to ornamental **spruce** trees throughout the Northeast and Midwest. Both insects cause the formation of cone-like galls on developing twigs, which deform, stunt and usually girdle them. Heavy and repeated infestations will seriously disfigure and weaken trees, and render them more susceptible to invasion by disease causing organisms and other insects.

Eastern Spruce Gall Aphid (Adelges abietis L)



Egg Mass on Norway Spruce

The Eastern spruce gall aphid was introduced into the United States from Europe in the early 19th century. The insect primarily attacks **Norway and white spruce**, causing the formation of pineapple-shaped galls approximately one inch long at the base of developing twigs. The Eastern spruce gall aphid overwinters as immatures

New galls on Norway Spruce Twig

or nymphs in bark crevices on twigs of its host. In early spring, nymphs mature and the winged adults lay eggs under a waxy cover on twigs. Eggs hatch about the same time new growth begins, and the young nymphs begin feeding near the base of expanding buds. Feeding induces the formation of the galls, inside which the nymphs continue to feed and develop. In late summer (August through September), galls open and fully-grown nymphs emerge. These become winged adults, which can fly to nearby susceptible spruce trees. The adults deposit eggs, which soon hatch and give rise to the overwintering nymphs.

Open new gall

The Cooley Spruce Gall Aphid (Adelges cooleyei Gill)

Cooley Spruce Gall on Colorado Blue Spruce

The Cooley spruce gall aphid is a native pest, which primarily infests **blue, Englemann and Sitka spruce and Douglas fir**. Galls caused by this insect are elongated, one to three inches long, and occur at the tips of twigs. The life cycle of this insect on spruce is similar to the Eastern spruce gall aphid. However, if Douglas fir is planted near spruce, some winged adults emerging from galls may migrate to Douglas fir and deposit eggs Nymphs emerging from eggs in late summer overwinter in bark crevices on twigs. In spring, the nymphs mature and another generation is produced on Douglas fir. Nymphs of this generation feed on the succulent new growth, causing needle distortion and browning; however, galls do not form. In mid- to late summer (mid-July through August), nymphs mature to form winged adults, which either migrate back to spruce or remain on Douglas fir. Adults deposit eggs on twigs of either tree species. The eggs soon hatch and give rise to the overwintering nymphs.

NON-CHEMICAL CONTROL

Removing and destroying green galls from spruce will reduce gall aphid populations. Removing brown, dried galls will have no effect on the pest population since the insect has already emerged from these galls.

CHEMICAL CONTROL

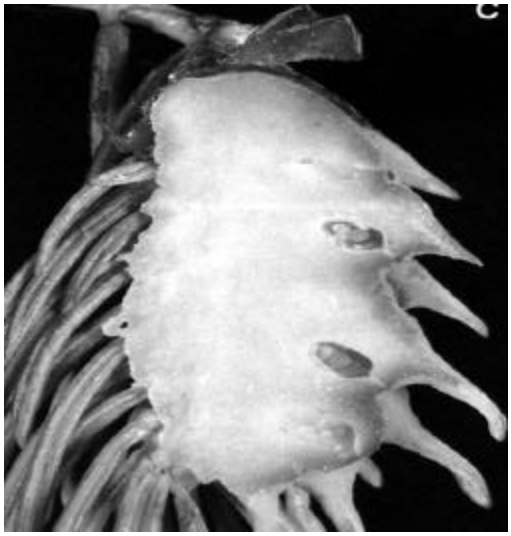
Spring application An application of dormant oil in early spring will effectively control overwintering nymphs and prevent gall formation. Oil should not be applied to blue spruce, since loss of blue color may occur.

A contact insecticide applied at budbreak will also control immatures and prevent gall formation. Proper timing is essential, since contact insecticides are ineffective once galls form.

Fall application An application of a contact insecticide in late September or early October will eliminate overwintering nymphs and prevent gall formation the following spring. Fall treatment is preferred since timing is less critical, and weather conditions are more conducive for spraying in fall than in early spring.

Consult the Bartlett Tree Research Laboratories Insect Control Recommendations or local state recommendations for a list of labeled insecticides and rates for control of these insects.

*For control of Cooley spruce gall aphid at either time of the year, both spruce and Douglas fir must be sprayed.



Opened Cooley Spruce Gall

PENNSTATE
Cooperative Extension - College of Agricultural Sciences
Woody Ornamental IPM

Spruce Spider Mite

The spruce spider mite, *Oligonychus ununguis* (Jacobi) is a common pest of landscape conifers in Pennsylvania. This tiny eight legged animal does best in the cool spring and fall weather with severe infestations causing discolored foliage, unthrifty looking plants and premature leaf drop. While feeding occurs in the fall and spring, often the damage does not become apparent until the heat of the summer.

Adult spruce spider mite

Plants Attacked

In Pennsylvania, spruce spider mites have been found on 43 different conifer species but are most commonly found on the following plants: Abies (fir), Juniperus (juniper), Thuja (arborvitae), Tsuga (hemlock), Picea (Spruce) and Psuedotsuga (Douglas-fir).

Webbing caused by spruce spider mite
Photo courtest of PA Dept. of Agriculture

Spider mite injury on dwarf Alberta Spruce
photo by Eric Vorodi

Identification

This oval shaped mite is small (about 1/50”), and with all eight legs stretched out would just cover the period at the end of this sentence. Considerable color variation exists depending upon their age, time of the year and host plant. Newly hatched larvae are pinkish in color, but turn dark green or dark red after initial feeding. The overwintering red eggs are found on the bark of small branches on the host plant. Many spider mites produce webbing, particularly when they occur in high populations, providing protection from natural enemies and heavy rainfalls.

Life History

Over-winter Red eggs found on the bark of small branches.

Spring Egg hatch occurs as early as mid-March, but most hatch by mid-April. Young mites feed on previous years foliage and do not attack the current season's growth until it hardens off in summer. Spider mites do best when daytime temperatures are in the 60's and 70's.

Summer When the daily temperatures consistently exceed the the mid 80's, adults become inactive and populations decline due to an increase in predatory mites and insects. If temperatures remain over 90 F for an extended period, the adults become dormant and lay tan or salmon colored eggs that only hatch when cooler temperatures return in late summer/early fall.

Fall Adult mite feeding activity resumes and continues until late fall. Adult female lay eggs on the bark of small branches, starting in early September and continuing until a hard frost occurs.

Damage Symptoms

Adults feed by inserting their mouthparts into the foliage and withdrawing plant fluids, resulting in a speckled appearance. This 'stippling' increases in intensity until the foliage can appear bronze or bleached depending upon the host plant. Severe infestations result in needle drop. Webbing of fine silk surrounding the needles and twigs often accompanies high populations, providing protection from natural enemies.

Monitoring

Scouting for spruce spider mite eggs can be done in late summer and early spring, just prior to the onset of the 60-70 degree temperatures favoring feeding activity. A hand lens with 10 or 15 power magnification is required. Adult mite activity can be assessed by holding a white piece of paper under a branch and striking the branch three or four times to dislodge the mites. Spruce spider mites will appear as tiny black or gray-green spots moving slowly on the paper.

Management Options

Biological	There are several naturally occurring predators of spruce spider mites in the landscape. Predatory mites, lady beetles, minute pirate bugs, and dusty wings can keep the spruce spider populations in check during the summer months but there is often a lag time between the build-up of spider mite populations and predators due to slower reproductive rates. Control of spider mites through the purchase and release of predators in the landscape is currently being researched.
Mechanical	Spider mites can be dislodged from plants during heavy rains. Spraying the plant with a steady forceful jet of water from a hose twice a week during periods of peak mite activity can greatly reduce the mite population and help conserve the natural predators.
Cultural	Spider mites thrive on plants under drought stress , so provide adequate water during dry periods.
Chemical	Most spider mites can be managed with the use of insecticidal soap or horticultural oils. Both of these products can remove the silvery blue-gray color from the needles of Picea pungens var. glauca and its many cultivars.

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Photos taken by the author unless otherwise noted
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