A Pocket IPM Scouting Guide for Woody Landscape Plants

Compiled and edited by:
Diane Brown-Rytlewski

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Project GREEEN

IPM Michigan State University

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Michigan Department of AGRICULTURE

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Illustrations on page 116, Steven D. Brown.

Introduction

This pocket IPM scouting guide for woody landscape plants was designed for field use. It contains information to help identify and manage common insects, mites and their injury, diseases, abiotic plant health problems, damage caused by animals, and common beneficial insects. It contains phenological indicator plants to use for monitoring pest insect stages. It is not intended to be all inclusive; there are many more pests than this guide can cover within its limited number of pages. References for more detailed information are listed within the guide. In addition to those, several comprehensive guides are listed below. Specific pesticides are not listed in this guide. Recommendations change frequently as new products become available and older ones are taken off the market. We suggest you contact your local Extension agent for current recommendations or use recommendations in the Extension Bulletin E-2782 *Pest Management Guide for Production and Maintenance of Trees and Shrubs*, available from the MSU Bulletin Office, 117 Central Services, Michigan State University, East Lansing, MI 48824-1039. Bulletins may also be ordered on the web at:
http://web2.msue.msu.edu/bulletins/mainsearch.cfm

Suggested reading

Insects that Feed on Trees and Shrubs 1994. W.T. Johnson and H.H. Lyon Cornell University Press, Ithaca, NY.

Diseases of Trees and Shrubs 1987. W. Sinclair, H.H. Lyon, and W.T. Johnson. Cornell University Press, Ithaca, NY.

Plant Health Care for Woody Ornamentals, 1997. J. Lloyd, Coordinating author. Printec Press, Champaign, IL

Index to listed pests/problems

Below is an alphabetical list of host plants. To find the pest, look up the host plant.

Insect/mites with multiple hosts:

Japanese beetle - over 300 hosts; **Twospotted spider mites** - over 150 hosts; **Aphids**; **Fall webworm** - around 88 hosts.

Deciduous trees

Alder (Alnus) - Cottony maple scale, gypsy moth, (alder) leaf miner.

Ash (Fraxinus) - Ash flower gall, ash plant bug, emerald ash borer, oystershell scale; (Shade tree) anthracnose, Verticillium wilt.

Birch (Betula) - Bronze birch borer, birch leafminer, potato leafhopper; Phytophthora root rot.

Beech (Fagus) - Fall webworm, cottony maple scale; beech bark disease (beech scale).

Crabapple (Malus) - Cottony maple scale, eastern tent caterpillar, fall webworm, flatheaded apple tree borer, gypsy moth, oystershell scale, potato leafhopper, rose chafer, (pear) slug sawfly; apple scab, Botryosphaeria canker, fireblight, powdery mildew, rust.

Elm (Ulmus) - Cottony maple scale, elm leaf miner, oystershell scale, rose chafer; Dutch elm disease, Verticillium wilt.

Flowering dogwood (*Cornus florida, C. kousa)*- Cottony maple scale; dogwood anthracnose, powdery mildew.

Flowering cherry, flowering plum (Prunus) - Cottony maple scale, eastern tent caterpillar, rose chafer, (pear) slug sawfly.

Hawthorn (Crataegus) - Cottony maple scale, eastern tent caterpillar, flatheaded apple tree borer, gypsy moth,

Hawthorn *cont.*- hawthorn leaf miner, pearslug sawfly, spider mites; fireblight, rust.
Honeylocust (Gleditsia) - Cottony maple scale, honeylocust plant bug, honeylocust spider mite; Phytophthora root rot
Juneberry (Amelanchier) - Pearslug sawfly, spider mites; fireblight, Verticillium wilt.
Kentucky coffeetree (Gymnocladus) - Verticillium wilt.
Linden (Tilia) - Cottony maple scale, flatheaded apple tree borer, gypsy moth, oystershell scale.
Magnolia - Phytophthora root rot, Verticillium wilt.
Maple (Acer) - Cottony maple scale, flatheaded apple tree borer, gall producing mites, gypsy moth, oystershell scale, potato leafhopper; (Shade tree) anthracnose, Phytophthora root rot, Verticillium wilt
Mountain-ash (Sorbus) - Eastern tent caterpillar, fireblight.
Oak (Quercus) - Cottony maple scale, flatheaded apple tree borer, gypsy moth, spidermites, twolined chestnut borer; (Shade tree) anthracnose, oak wilt, Phytophthora root rot.
Redbud (Cercis) - Botryosphaeria canker, Verticillium wilt
Sycamore (Platanus) - Cottony maple scale, spider mites; (Shade tree) anthracnose, Phytophthora root rot.
Tuliptree (Liriodendron) - Verticillium wilt.
Willow (Salix) - Cottony maple scale, crown gall, gypsy moth, oystershell scale; Phytophthora root rot.
Walnut (Juglans) - Cottony maple scale, fall webworm, oystershell scale; anthracnose,Phytophthora root rot.
Yellowwood (Cladrastis) - Verticillium wilt.

Needled evergreen trees/shrubs

Chamaecyparis - Juniper scale, spruce spider mite; tip blight.

Index - *continued*

Shrubs

Abiotic injury

Animal damage

Natural enemies

Insects and mites
Aphids

Numerous aphids feed on trees and shrubs in the landscape. They may occur throughout the season when plants are actively growing. Some are vectors for viral diseases of plants.

Symptoms: Aphids suck plant sap from leaves and stems causing distorted growth, yellowing of foliage and premature leaf drop. Aphids also excrete honeydew, a sticky substance that sooty mold fungi can grow on.

Aphids are soft-bodied, pear-shaped, and can be distinguished from other insects by their tailpipe-like cornicles used to secrete pheromones. Cornicle length and shape are used as identifying characteristics of aphids.

Distorted growth on hawthorn caused by aphids

Giant willow aphid

Aphids - *continued*

Management: Aphids have many natural enemies, including syrphid fly larvae, lacewings, lady beetles and parasitic wasps. Soaps, oils and other insecticides are also effective.

Aphid species range in size from about 1.5 mm to 4 to 5 mm (giant willow aphid).

Wooly alder aphids, *Paraprociphilus tesselatus* are shown here on silver maple. The white covering is made up of strands of wax.

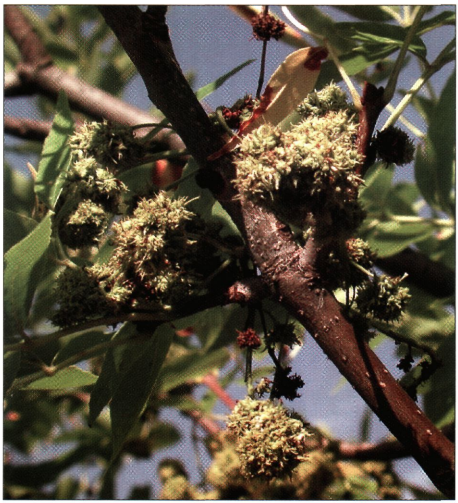
Witches' brooms on Tataruian honeysuckle caused by the honeysuckle aphid, *Hydaphis tataricae*.

Ash flower gall mite
Eriophyes fraxiniflora

This cigar-shaped mite is one of a group of eriophyid mites that cause galls to form on plants. It affects only male ash trees, causing a proliferation of flower buds to form, which results in unattractive galls. Although the galls are unsightly, they aren't harmful to the tree since they only affect the flowers. Galls start out green, then turn brown to black and persist over the winter.

The size of the mite is less than 0.5 mm.

Management: No treatments are necessary, but galls may be pruned off to improve the tree's appearance.



Ash flower gall affects only male flowers.

Ash plant bug
Tropidosteptes amoenus

Injury from ash plant bug can be seen on leaves of ash trees. They overwinter as eggs under the bark of ash trees and hatch around the time redbud is in flower. There are two generations per year. Second generation nymphs continue to feed on the lower leaf surface. There is a characteristic green heart-shaped mark inside of a triangular structure in the middle of the insect's back.

Adult ash plant bugs are about 1/4 inch long with green and brown markings.
1/4 inch

Management: Treatment is rarely needed as lasting damage to the trees rarely results from ash plant bug feeding.

Nymphs feed on the underside of leaves, creating stippled or mottled patches of yellow and white visible on the upper surface of the leaves. Small tar-like spots of excrement may be present on the undersides of leaves. As injury progresses, dead areas may appear along the leaf margins.

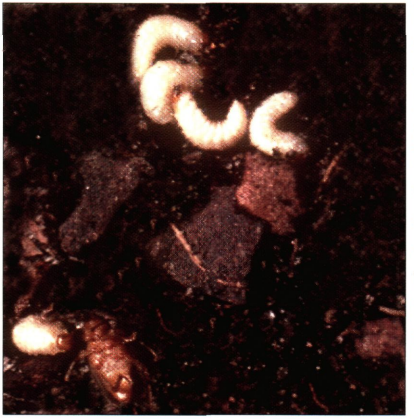
Black vine weevil
Otiorhynchus sulcatus

These snout beetles overwinter in the soil as early instar grubs, or as adults. Look for feeding by over-wintering adults *as Viburnum opulus* or *Weigela* are blooming. Look for over-wintering larvae to emerge as adults as *Hydrangea arborescens* 'Grandiflora' or 'Annebelle' are blooming. Adult weevils (all female) lay eggs for extended periods during the summer.

10 mm long

Adults weevils are active at night, but can be detected during the day by laying down boards or using pitfall traps.

Larvae are 9 mm long



Larvae and pupae of black vine weevil are found in the soil. Larvae cause serious injury by feeding on the bark of roots and stems. Foliage of plants injured by weevil larvae may turn brown or die suddenly.

Black vine weevil - *continued*

Hosts: Azalea, rhododendron, euonymus, hemlock and yew.

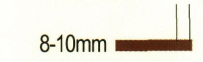
Management: Management is usually targeted toward adults. Contact your Extension agent for recommendations.

Typical leaf notching caused by adult weevils feeding on foliage.

Bronze birch borer
Agrilus anxious

Bronze birch borer is a pest of birch trees, especially white barked birches such as *Betula papyrifera*, *B. populifolia, B. pendula and B. maximowicziana. B. papyrifera* is much more tolerant of bronze birch borer than *B. pendula.* Insects overwinter as larvae in galleries in the vascular system and resume feeding in spring as the sap rises. Adults emerge over a period of about 6 weeks beginning in late May or early June when pagoda dogwood and 'Winter King' hawthorns are in full bloom. Females lay eggs on the bark, and larvae hatch out and begin boring into the bark around the time that European cranberry-bush viburnum or weigela are in bloom. Larvae form winding galleries in the cambium of the tree, girdling branches and disrupting the flow of water and nutrients in the tree. Larvae may take up to two years to complete their development.

Adults are similar in shape to twolined chestnut borers (photo on page 49) but are 8-10 mm long and a dull metallic bronze in color.



Lumpy branch is symptom of bronze birch borer.

Bronze birch borer - *continued*

Symptoms: Bronze birch borer injury includes dieback that begins in the upper portion of the tree, a lumpy appearance to branches where galleries are present, and D-shaped exit holes in the bark created by emerging adults. Rusty-colored stains may also be visible on bark in the area of entrance or exit holes.

Management: Stressed trees are much more prone to injury. Avoid planting birches in hot, dry sites. Help keep trees healthy through proper mulching and watering. Once injury occurs, damage may be pruned out if it isn't too extensive. Plant resistant birches, such as 'Heritage' (*Betula nigra* 'Heritage') and river birch (*Betula nigra*). If using insecticide treatments, target the young larvae before they tunnel into bark, around the time that *Viburnum opulus* or *Weigela florida* are in bloom.

Dieback in upper portion of tree.

Cooley spruce gall adelgid
Adelges cooleyi

This insect can produce continuous generations on either Colorado spruce or Douglas-fir but normally spends a portion of its two-year life cycle on each host.

Gall sliced open to show nymphs in chambers.

Overwintering females on spruce lay eggs near developing buds. Nymphs hatch as bud caps split. Nymphs feed at the base of developing buds in spring producing cone-like galls on the tips of blue spruce branches. Galls open in mid-summer. Emerging adelgids either continue to live on spruce or fly to Douglas-fir to lay eggs. On Douglas-fir they may continue to live or produce a generation that flies back to spruce to produce the gall-forming stage. On Douglas-fir, feeding on needles by nymphs produces yellow spots and curled needles but no galls.

Right: Opened Cooley galls on Colorado spruce. Left: Adelgids on Douglas-fir. **See management, page16.**

Cottony maple scale
Pulvinaria innumerabilis

Cottony maple scale is found primarily on silver maple and honeylocust; rarely on alder, box-elder, catalpa, elm, dogwood, hackberry, hawthorn, crabapple, oak, plum, pear, cherry, linden, lilac, willow, beech, poplar, and sycamore. These insects overwinter as immature females on twigs. Females mature and white egg sacs develop in June, when 'Snowmound' spirea or mock-orange are in full bloom. Copious amounts of honeydew may be produced. Look for crawlers as littleleaf linden begins bloom, or *Hydrangea arborescens* 'Grandiflora' or 'Annebelle' are in full bloom. Crawlers live on the leaves near veins during summer and migrate back to twigs in fall before the leaves drop.

Egg sacs of cottony maple scale.

Management: Twice-stabbed lady beetles and certain wasps and flies are among the natural enemies that help to control cottony maple scale. Insecticides are rarely needed in the landscape due to natural enemies and tolerance of trees.

Eastern spruce gall adelgid
Adelges abietis

Norway spruce is the most common host for this adelgid. Females overwinter near buds and lay eggs at bud bases when buds begin to break. Galls produce stunted and deformed shoots. Galls turn red and open from around mid-August to October, at which time adults emerge and reproduce.

Management: Horticultural oils can be used to treat the overwintering stage when trees are dormant. Insecticides are more effective in mid-April to early May before the candles open. Cut off and destroy galls before they open. A soil application of insecticide may also work well in fall. Contact your local Extension agent for current recommendations. Avoid planting Colorado spruce and Douglas-fir together to reduce the severity of Cooley spruce gall.

Feeding of nymphs on developing needles caused the characteristic pineapple-shaped galls (3/4- to-1 inch long) to form at the bases of new shoots. These galls have already started to turn red.

Eastern tent caterpillar
Malicosoma americanum

Favored host plants: Apple, crabapple, hawthorn, cherry, mountain-ash, cotoneaster and other members of the rose family. Eastern tent caterpillars overwinter in egg masses on twigs of the host plant.

Mature larva of the eastern tent caterpillar.

5 cm long

Larvae normally hatch at about the same time that the host plant is beginning to leaf out. Look for young larvae around the time that Norway maple or Amelanchier are in bloom.

Egg masses can be found encircling twigs throughout the winter and early spring. This is an older egg mass where larvae have already hatched. The egg masses should be removed before young larvae hatch.

Eastern tent caterpillar - *continued*

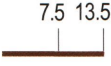
Management: Remove egg masses, or prune out webs while they are still small. Removing webs should be done on a cloudy or rainy day, when caterpillars are inside the web. If insecticide treatments are used, the web should be broken open, as the tents provide protection from some insecticide applications.

Bottom left: Larvae create silken tents in the branch crotches and emerge from the tent to feed. Bottom right: As larvae mature, they leave the host plant and look for a place to make their cocoons. The adults emerge in late June or early July.

Emerald ash borer
Agrilus planipennis

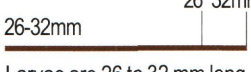
All ash species (*Fraxinus*) grown in Michigan are hosts for emerald ash borer (EAB). Mountain ash (*Sorbus*) is not a host.

The EAB adult is dark metallic green from about 7.5-13.5 mm long. Females are larger than males.



7.5-13.5mm

In southern Michigan, EAB seems to have a one year life cycle but it could require two years in colder regions. Adult emergence is from about early June to mid-August. Females lay eggs on the bark of trunks or branches. Eggs hatch in 7 to 10 days. Larvae tunnel into the cambium, where they create S-shaped feeding galleries, packed with fine frass. Larvae are creamy white in color and are found under the bark. Larvae pupate in late April to early May. Adult beetles create a D-shaped exit hole when they emerge from the trunk a few weeks later.



Larvae are 26 to 32 mm long, cream-colored and are flattened like a long, narrow piece of cardboard.

Emerald ash borer - *continued*

Symptoms: Look for D-shaped exit holes (about 3-4 mm in dia.) on branches and the trunk. Canopies of infested trees thin out and branches die from being girdled by larvae feeding under the bark. Watersprouts form on the trunk at the juncture of live and dead tissue. Trees usually die after several years of heavy tunneling.

Management: This pest is quarantined in Michigan. Efforts are being made to limit its spread, and track locations where it is found. Send suspect samples from outside the known area of infestation to MSU Diagnostic Services for positive identification by an expert. Drought stress may make trees more vulnerable to attack by EAB, but healthy trees are also attacked. Several systemic insecticides for larvae and sprays for adults are currently under evaluation for their effectiveness against EAB. In general, treatments will be similar to those used for bronze birch borer. Consult your local Extension agent for current recommendations. For more information visit the MSU website: http://www.emeraldashborer.info

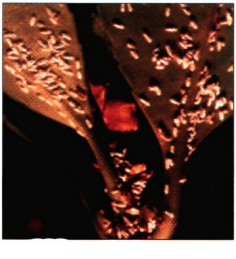
Bark removed to show S-shaped galleries caused by larval feeding.

Euonymus scale
Unaspis euonymi

Hosts: Evergreen species of euonymus, as well as pachysandra, English ivy and boxwood. It is not found on burning bush. Mature females overwinter on stems and leaves. They begin to produce eggs under the scale coverings in early spring. Eggs hatch in late May to early June, and crawlers emerge for about 2 to 3 weeks. There may be 2 to 3 generations per year. Evidence of scale infestation includes yellow spots on leaves, defoliation, and a heavy crust of scales on the stems. Severe infestations can kill the plants.

2mm

Female scale (above) is gray to brown, male (below) is slender and white; both are about 2 mm long. The two yellow objects by the female are crawlers.



Management: Target the crawler stage for treatment with horticultural oil. Look for the first generation of crawlers from around the time black locust is in full bloom to when Japanese tree lilac and catalpa are in bloom. The second-generation crawlers emerge in mid-August. The twice-stabbed lady beetle, *Chilocorus kuwanae*, is an introduced natural enemy of euonymus scale.

European pine sawfly

Neodiprion sertifer

Hosts:
Scotch, mugo, red, Japanese red, jack and Swiss mountain pines and occasionally others. Eggs of the European pine sawfly are laid in slits on current year's needles in late summer and fall. Larvae emerge the following spring to feed on two-year old needles. Look for young larvae as Amelanchier is blooming or redbud begins bloom in late April to mid-May.

Sawflies have 6 or more pairs of prolegs, fleshy outpouchings of abdominal tissue that resemble legs. Caterpillars have 5 or fewer pairs of prolegs.

Pine needle, where European pine sawfly eggs were laid the previous summer. The egg on the right is about to hatch.

Late feeding damage.

European pine sawfly - *continued*

Management: Larvae feed in groups; both larvae and their damage can be pruned out. Insecticides should be targeted to younger larvae. Remember, *B.t.* is not effective on sawfly larvae even though they resemble caterpillars. See page 116 for identification tips.

Sawfly larvae, which resemble caterpillars, feed in a group, eating all the second-year needles before moving on to new branches.

Early feeding damage on mugo pine.

Fall webworm
Hyphantria cunea

Fall webworms feed on at least 88 different species of plants in the U.S. Favorite host plants include black walnut, wild cherry, hickory, crabapple and birch. Larvae pass through as many as 11 instars on their way to developing into adults. They create silken tents on the ends of the branches. Look for developing larvae as goldenrods begin to bloom.

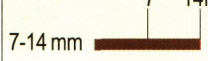
Management: Because they occur so late in the growing season, there is usually no need to control webworm. Unsightly webs can be pruned out or dislodged with a strong stream of water. Unlike eastern tent caterpillars, these caterpillars stay in the web while feeding, so pruning the webs at any time of day will eliminate them.

Young larvae developing on a walnut leaf. Webworms have many natural enemies including birds, predaceous bugs and parasitic wasps. Leaving the webs intact allows populations of their natural enemies to develop.

Flat-headed apple tree borer

Chrysobothris femorata

Flat-headed apple tree borer adult (at left) is 7 to 14 mm long with a metallic, dark bronze color.



This is a common pest of newly planted trees and shrubs, including maples, crabapple, hawthorn, linden and oak. Eggs are laid near bark fissures or wounds and hatch around the time mock-orange blooms.

Management: Avoid leaving tree wrap on for more than a season. Larvae may be found injuring the bark underneath tree wrap that has been left on for extended periods of time. If injury is not extensive, damaged areas of bark can be cut back to healthy tissue and larvae can be removed. Keep newly planted trees and shrubs well watered and mulched, as stressed plants are more prone to injury by this insect. Adults are stouter than either two-lined chestnut borers or bronze birch borers.

Larvae feed in the cambium and sapwood. Look for darkened patches of bark from oozing sap and fine bits of frass on the trunk.

James Solomon, USDA Forest Service, www.forestryimages.org

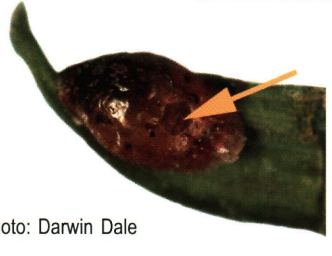
Fletcher scale

Parthenolecanium fletcheri

Hosts: Yew and arborvitae.This insect overwinters as a small, reddish brown nymph on twigs and needles. Vulnerable overwintering females (before egg production occurs) are present as redbud and Koreanspice viburnum are in bloom. Look for crawlers as elderberry or 'Hills of Snow' hydrangea are in bloom.

Management: This is primarily a nursery pest and is not usually observed in the landscape. In the landscape, natural enemies, including several small wasps, often control Fletcher scale.

Brown ovals on twigs are scales; examine the interior branches of the shrub and look for sooty mold.



Arrow points to hole in scale caused by one of the tiny wasps that are internal parasites.

Photo: Darwin Dale

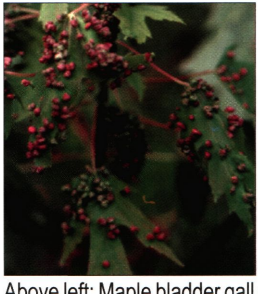
Gall-producing mites
Eriophyidae

Mites in this family are responsible for producing galls and dense patches of hair or beadlike growth called erinea on a number of plants. Several commonly seen galls are: maple spindle gall, maple bladder gall, and erineum on maple.

The size of the mites is less than 0.5 mm.

Management: Treatment is not usually not necessary, as lasting harm to plants rarely occurs.

Maple spindle gall on sugar maple.



Above left: Maple bladder gall on silver maple. Above right: Erineum patches on undersides of silver maple leaves.

Gypsy moth
Lymantria dispar

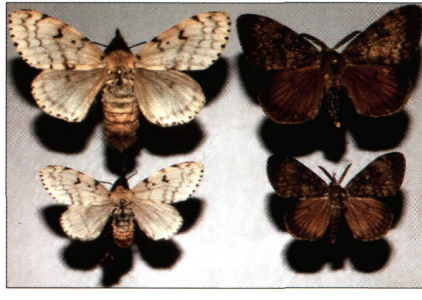
Hosts: Oak, maples, alder, willow, poplar, apple, hawthorn, elm and linden. However, many plants, including some conifers, are eaten.
Look for larvae to hatch in late April to early May as Bradford pear or Amelanchier are blooming. Larval development takes about seven weeks.

Young larvae are dark with irregular yellow marking on their backs and a black head capsule. As larvae mature (fourth to sixth instars), they develop 5 pairs of blue spots and 6 pairs of red spots on their backs.

Gypsy moth overwinters in the egg stage in an egg mass laid on the tree and covered with a dense patch of hairs. The buff-colored egg mass under the female moth is new; the lighter-colored mass on the bottom is an old egg mass (from the previous year).

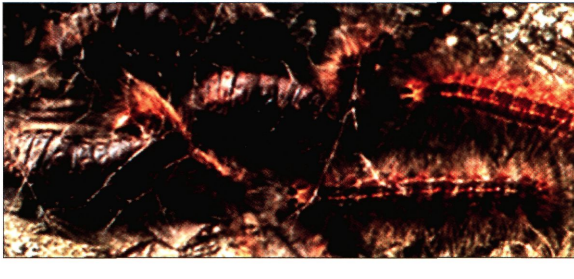
Gypsy moth - *continued*

Females are creamy white with a wingspan of about 2 inches; males are brown with darker bands. Females cannot fly — they call in males with pheromones, mate, and lay eggs near their pupation sites. Egg masses are laid in July to August.



Left: female gypsy moths, Right: male gypsy moths. Larger moths are from areas with lower populations, smaller ones from more densely populated areas.

Moths pupate in protected sites, like under loose flaps of bark or on woodpiles. Adults emerge after pupation (about 10 to 14 days) beginning about mid-July to mate and lay eggs.



Gypsy moth - *continued*

Management: When using insecticides to manage gypsy moth, target young larvae. Although the caterpillars can be a nuisance, insecticide sprays are not necessary to protect trees if there is less than 30 percent defoliation.

Pheromone traps can be used to time the emergence and flight of adult male gypsy moths. Look for and destroy egg masses in late summer and fall. Gypsy moth has many natural enemies, including predators, parasitoids and pathogens. NPV (a virus), shown infecting the caterpillar in the photo, may cause a significant drop in populations within a couple of years of an outbreak.

Larva infected with NPV (nuclear polyhedrosis virus)

William M. Ciesla, Forest Health Management International, www.forestryimages.org

Honeylocust mite

Eotetranychus multidigituli

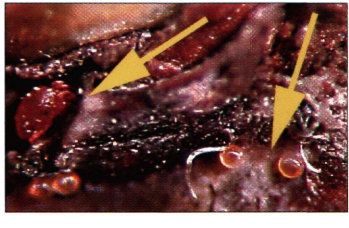
This mite's only host is honeylocust. It overwinters as a red, adult female in bark crevices, twigs and bud scales. There are multiple generations per year. Egg laying begins early in the season, around mid-April as Cornelian cherry blooms. Eggs are deposited near developing buds. Nymphs start out pale yellow and darken to green as they develop. Symptoms of injury include yellowing and stippling of leaves and early defoliation of leaflets in July and August. Use a hand lens to look for mites on undersides of leaflets, or shake branches over a white sheet of paper.

Defoliated tree in late summer.

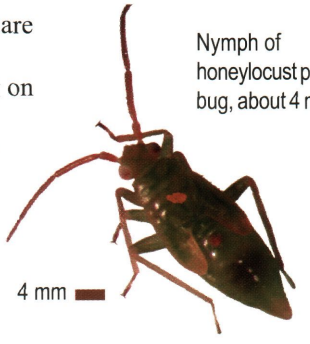
The size of the mites is less than 0.3 mm.

Management: Treat overwintering mites before egg laying begins. Adults and nymphs are vulnerable to many miticides, including soaps and oils. Check mite populations in mid-summer and treat if needed. Trees usually survive late season defoliation.

Female adult (left arrow) and eggs laid at base of honeylocust leaf bud (right arrow).



Honeylocust plant bug
Diaphnocorus chlorionis
Honeylocust leafhopper
Macropis fumipennis



Nymph of honeylocust plant bug, about 4 mm long

These two insects are often found at the same time feeding on honeylocusts, but plant injury is due almost entirely to the plant bug. Honeylocust plant bugs overwinter under bark as eggs. They hatch and begin feeding as new leaves develop, from late April to mid-May. Nymphs mature into adults in about one month. There is one generation per year.

4.5 mm

Leafhopper adult about 4.5 mm long.

Honeylocust plant bug - Honeylocust leafhopper - *continued*

Management: Look for nymphs as saucer magnolia and bridalwreath spirea are in bloom. Determine population levels by tapping terminals over a white piece of paper. The insects will be visible on the paper. Treatment may not be necessary, unless trees are heavily infested.

Honeylocust leaves distorted and stunted from feeding injury caused by plant bug adults and nymphs. Defoliation may occur on severely infested trees.

Japanese beetle
Popillia japonica

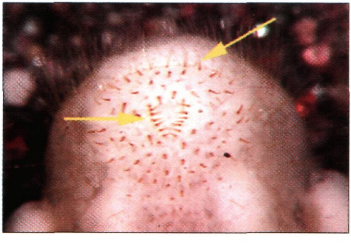
Host range: Around 300 different species. Lindens, red-leaf and variegated cultivars of Norway maple, wild grape, as well as members of the family Rosaceae (amelanchier, crabapples, mountain ash, purple leaf plum, roses and others) are particularly favored.

Look for adult beetles in late June to early July, as littleleaf linden begins bloom and Hills of Snow hydrangea is in full bloom. Adults often feed in a group, skeletonizing leaves with only a network of veins remaining when feeding damage is heavy. Larvae damage roots of turf.

Japanese beetle adults can be confused with the false Japanese beetle (*Strigoderma arboricola*) and rose chafers. Although all three have copper colored wing covers, only Japanese beetle has tufts of white hairs along the outer edge of the abdomen.

Japanese beetle - *continued*

Management: Beetles are attracted to plants damaged by feeding, so control damage early. Pheromone traps and bait traps are not recommended as a strategy for trapping out beetles. Traps contain a floral lure to attract female beetles and a pheromone to attract males. It is possible to draw in more beetles from surrounding areas and to have greater damage resulting, particularly if traps become full.



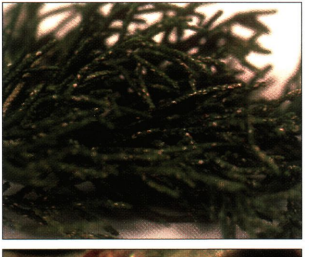
Typical white grub; arrow at raster. Rastral patterns are used to ID grubs. Lower photo: Anal slit is straight, pali (bottom arrow) less than 14.

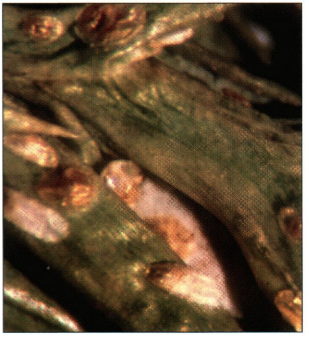
See the MSU plant diagnostic clinic web site for more detailed information on identifying grubs: *Identifying Common White Grubs in Michigan* at: http://www.cips.msu.edu/diagnostics/profiles/index.htm

Juniper scale
Carulaspis juniperi

Hosts: Juniper, arborvitae and chamaecyparis. An infestation of this armored scale causes off-color foliage, yellowing and dieback of juniper needles. Severely infested junipers may have little to no new growth. Female scales overwinter as adults with eggs; there is one generation per year. Look for crawler emergence beginning early to mid-June, around the time Washington hawthorn or Japanese tree lilac is in bloom.

Management: Several parasitic wasps are among the natural enemies of juniper scale. The overwintering adult female is vulnerable; otherwise the crawler stage should be targeted for treatment with insecticides.



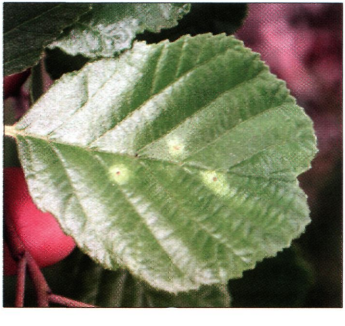


1.5mm ■

Male scales are elongate; females are round and 1.5 mm in diameter.

Leaf-mining sawflies

Hosts: Birch leafminer *(Fenusa pusilla),* Elm leafminer *(Fenusa ulmi),* Alder leafminer *(Fenusa dohrnii)* and Hawthorn leafminer *(Profenusa Canadensis).* The larvae of all of these leaf-mining sawflies feed on leaf tissue between the upper and lower surfaces of the leaf, causing papery brown blotches to appear on the leaves. The adult females lay eggs in leaf tissue with their ovipositors when leaves are about half grown. Adults are black, about 3 mm long, except for alder leafminer (6 mm) and resemble small flies. Larvae are translucent, yellowish-white with greatly reduced prolegs.



3mm

6mm

Top: Adult leafmining sawfly. Bottom: Egg laying sites on alder leaf.

Leaf-mining sawflies - *continued*

Management: Target young larvae with systemic insecticides. Look for birch leaf miner larvae as Vanhoutte spirea or European cranberry-bush viburnum are blooming. Newly developing larvae of hawthorn, alder and elm leaf miners are present a little later as black cherry or black locust begin bloom. There may be several generations per year, depending on the weather.

Blotches on alder leaf -- caused by alder leafminer.

Top right: Sawfly larva from hawthorn. Left: Elm leafminer injury.

Oystershell scale

Lapidosaphes ulmi

This armored scale has two forms (lilac and apple) that attack numerous hosts, including ash, lilac, maple, willow, crabapple, linden, elm and others. It overwinters as eggs, which hatch in mid-May, when black cherry or blackhaw viburnum are in full bloom. No honeydew is produced.

Symptoms of oystershell scale include dieback of branches and twigs, yellowed or undersized foliage and an unthrifty appearance, as shown on this Carolina silverbell.

Scales with exit holes caused by emerging parasitic wasps.

Oystershell scale - *continued*

Management: Target first generation crawlers with insecticides or oil. The first generation of crawlers should have emerged by the time S*pirea* x *vanhouttei* is in full bloom, in mid- to late May. There is one generation of the lilac form and two of the apple form per year. Twice-stabbed lady beetles and parasitic wasps are natural enemies of oystershell scale.

3mm

Brown-to-grayish oystershell shaped scales, about 3 mm long, form a crust on the bark.

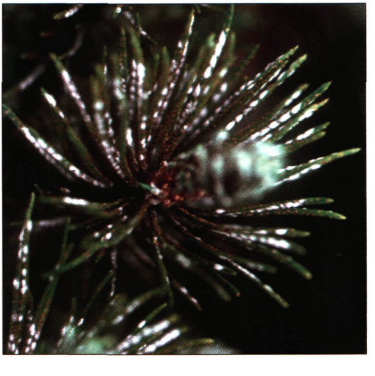
Pine needle scale
Chionaspis pinifoliae

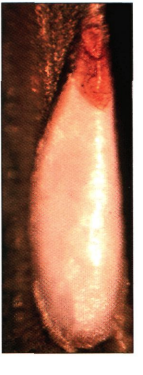
Hosts: Pine and spruce.
It overwinters in the egg stage under the scale covering; there may be two generations. Eggs and first instar crawlers are red; later instars are yellow. Look for the first crawler stage as Vanhoutte spirea or common lilac are in bloom.
Second generation crawlers are present during bloom of *Hydrangea arborea* 'Grandiflora' or 'Annabelle'. Branches infested with pine needle scale may turn yellow and have poor growth. Heavily encrusted branches may appear stunted.

Management: Several small wasps feed on pine needle scale. Spray infested branches with a horticultural oil when crawlers emerge in mid-May (spirea or lilac bloom). Dead scales will remain on needles for a year or longer.

3mm

Pine needle scales, 3 mm long.

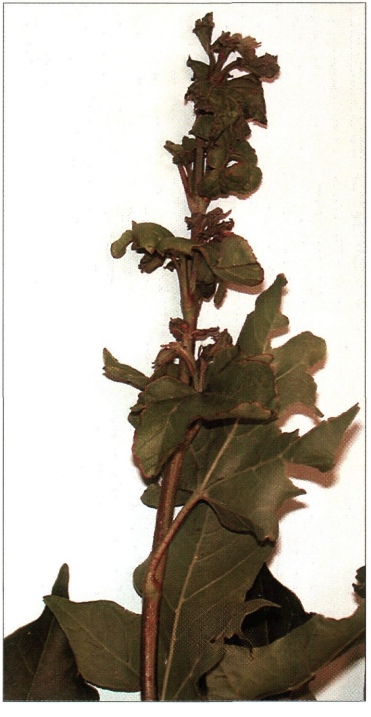




Potato leafhopper

Empoasca fabae

Potato leafhopper is a pest of many agricultural crops. Trees most likely to be damaged are maples (especially red, Norway and sugar), birch, apple and crabapple, and viburnum. Potato leafhoppers overwinter in the southern U.S. along the Gulf Coast and travel to the north via wind currents and storms, usually during May to mid-June. The result of their feeding is apical growth with stunted, curled leaves that resembles herbicide injury.



Potato leafhopper - *continued*

Management: Potato leafhoppers have many natural enemies that may help reduce their numbers in the landscape. However, damage to red maples is common, especially in rural areas. Scout by looking for the white-eyed, yellow-green nymphs and adults on the undersides of leaves. The leafhopper runs sideways when disturbed. Examine four shoots, one on each side of the tree. According to Dr. Cliff Sadof of Purdue University, consider using an insecticide if an average of three leafhoppers per shoot (12 insects per four branch samples) is found.

Adult leafhoppers are about 3.2 mm long; nymphs are even smaller; white object is shed skin.

3.2 mm

Rose chafer
Macrodactylus subspinosis

Hosts: Rose, flowering cherry, crabapple, hydrangea, elm, elder, wisteria and several herbaceous perennials. The larvae overwinter as grubs in the soil, pupate in early spring and emerge in June. Look for adults as beautybush and European cranberrybush (*Viburnum opulus*) are blooming. Grubs feed on the roots of grasses, weeds, trees and shrubs, and are found in sandy soil. Rose chafers particularly favor feeding on rose flowers. Leaves skeletonized by rose chafers look very similar to those damaged by Japanese beetles.

Management: Floating row covers or netting may be used as barriers to protect plants, but may not be practical where plants are large or numerous. A pheromone trap specific for rose chafer is commercially available. This insect has few natural enemies and is poisonous to birds. Target the adult stage with a registered insecticide.

12mm

Adult rose chafers are about 12 mm long with reddish-brown legs and buff to tan bodies. They lack the white tufts of hairs along the abdomen and metallic color of Japanese beetles.

Roseslug, *Endelomyia aethiops,*
Bristly roseslug, *Cladius difformus*
Pear sawfly, *Caliroa cerasi*

The adults of all slug sawflies are small and wasp-like. Adult females lay eggs in the leaf, and larvae skeletonize the leaves after they hatch and begin to feed. Roseslug sawflies feed solely on roses. Leaves are skeletonized along the upper and lower leaf surfaces, leaving only the veins and causing the leaf surfaces to turn brown. Look for larvae beginning in May through the end of June. There is one generation per year. Larvae are bright green with orange head capsules. Mature larvae are 19 mm. The bristly roseslug, (not shown) is covered with bristlelike hairs and chews holes in the leaves as it matures. It has 5 to 6 generations per year. Pearslug sawflies have a wider host range, including pear (not Bradford pear) crabapple, mountain ash, cherry, cotoneaster, amelanchier, and hawthorn. Pearslugs are dark olive green, slimy, and swollen at the head end. They overwinter in the ground as full-grown larvae, pupate and emerge as adults around late May to early June.

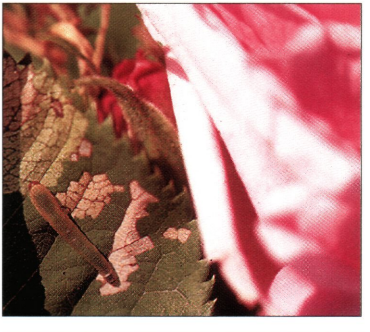
Roseslug larva

19 mm

Slug sawflies - *continued*

Larvae feed in a group for about 3 to 4 weeks and may cause considerable leaf damage.

Management: Little is known about natural enemies. Dislodge larvae with a strong jet of water. Insecticidal soaps may be effective, but be sure to check the label for phytotoxicity to host plants. There are several insecticides labeled for use on slug sawflies; *B.t.* is not effective on sawflies.

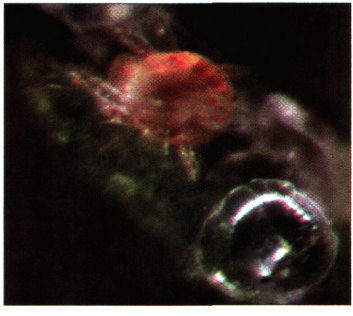


Roseslug injury.

13 mm

Pearslug larvae have characteristic window feeding.

Spruce spider mite
Oligonychus ununguis



This mite overwinters in the egg stage on buds and needles. It is active during cooler weather in spring and fall. Nymphs are present in spring as saucer magnolia or Norway maple begins to bloom. Look for active spruce mite infestations in the fall as goldenrod is blooming. Hosts for spruce spider mite include fir, pine, yew, arborvitae, juniper and Douglas-fir.

Spruce spider mite - *continued*

Damage: Look for stippled needles, especially on older growth. Mites will be visible with a 10x hand lens. Old eggshells will be clear; viable eggs are red. Young nymphs are red, turning dark green as they mature. Webbing may be present.

Management: Sampling mite populations by shaking an infested branch over white paper will help to estimate populations. Low numbers may be controlled by predatory mites (see "natural enemies" page 104) if they are present. If miticides are needed, select specific miticides that spare predators.

The size of the mites is less than 0.5 mm.

Twolined chestnut borer

Agrilus bilineatus

Twolined chestnut borer is primarily a pest of oaks. Adults, found from mid-June through September, are rarely seen. They lay their eggs in bark fissures and cracks around late June or early July. Larvae burrow into the bark and feed in the phloem. Larval development may take up to two years. Emerging adults chew a D-shaped exit hole in the bark. Injury symptoms begin in the upper part of the crown and proceed downward.

Adult is a metallic wood boring beetle (Buprestidae) 10-13 mm long.

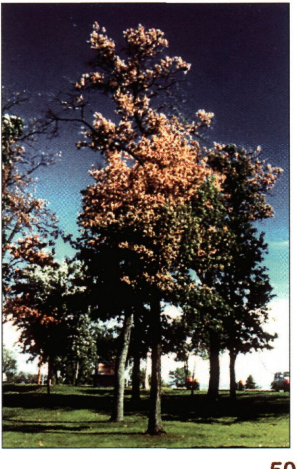
Trees exhibit sparse foliage, chlorotic leaves and dieback. D-shaped exit holes (about 1/8 inch in diameter) may be visible in the upper part of the tree. Long, winding galleries packed with frass can be found under the bark in areas where larvae are present.

Twolined chestnut borer - *continued*

Management: Stressed trees are much more prone to injury. Help keep trees healthy through proper site selection and watering; protect from construction injury. Once injury occurs, damage may be pruned out if it isn't too extensive.

Above left: Larvae of buprestids are commonly known as flat-headed borers due to the broad, flattened thorax, as shown on the larva in the photo. Below right: A layer-cake effect of dying and live branches occurs on oaks infested with twolined chestnut borers.

Below: Bark removed to show galleries of twolined chestnut borers.



Twospotted spider mite
Tetranychus urticae

Twospotted spider mites have a wide host range. They can be found nearly any time of year, especially during hot, dry weather. Multiple generations occur each season.

Adults: 0.7 to 1 mm.
1 mm ■

Look for bronzed or bleached foliage. Leaves may have a stippled appearance and webbing may be present. Mites balloon on webbing to reach new food sources

Management: Mites are not insects; many insecticides are not effective against mites. When choosing specific miticides, look for those that will spare predatory mites. Predatory mites and other natural enemies help to control populations. Soaps and summer oils can also be effective, and won't have as lasting an impact on natural enemies.

Diseases

Specific pesticides are not listed in this guide. Recommendations change frequently as new products become available and older ones are taken off the market.

We suggest that you contact your local Extension agent for current recommendations or use the recommendations in the Extension Bulletin E-2782 *Pest Management Guide for production and Maintenance of Trees and Shrubs*, available from the MSU Bulletin Office, 117 Central Services, Michigan State University, East Lansing, MI 48824-1001.

Bulletins may also be ordered on the web at: http://web2.msue.msu.edu/bulletins/intro.cfm

Where disinfesting tools is recommended for disease management, a solution of 10 percent household bleach (1 part bleach to 9 parts water), Green-shield(R) (a brand of quaternary ammonia labeled for this purpose), or 1.25 oz per gallon of ZeroTol™ can be used to clean tools.

Apple scab

Cause: *Venturia inequalis* (fungus)
Hosts: Crabapples and apple vary widely in their resistance to scab. Related (but different) species of the fungus that cause apple scab produce scab on hawthorn, mountain ash and pyracantha.

Symptoms: Symptoms (below) appear as velvety, olive green spots on leaves varying in size from a pinhead to 1/2 inch. As lesions enlarge, they run together and form larger areas. Leaves turn yellow and drop off in mid summer. Severely affected trees can be nearly defoliated by September. Fruits may also develop rough, corky, brown spots.

How it's spread: The fungus produces two types of spores. Sexual spores are produced on fallen leaves infected the previous year, to infect new leaves by wind and splashing rain. Subsequent infections spread on the tree through asexual spores (called conidia) via wind and rainsplash. The disease is more severe in years with wet spring weather.

Apple scab *continued*

Management: Rake up and remove infected leaves from underneath trees. Avoid overhead watering. Apple scab is never fatal but disfigures the tree and reduces vigor. Plant resistant cultivars where possible; see listing below. Registered fungicides can be applied preventatively at 2-week intervals beginning at budbreak until after petal fall.

Resistant crabapples may develop spots on their leaves, but retain their leaves, so the scab is less noticeable.

A partial listing of crabapples evaluated by Michigan State University reported as having no scab to slight scab (with no defoliation) include the following (listed alphabetically): *Malus baccata* 'Jackii', 'Beverly, 'Bob White', 'David', *M. floribunda*, 'Harvest Gold', 'Liset', 'Mary Potter', 'Ormiston Roy', 'Prairifire', 'Professor Sprenger', 'Red Jewel', 'Red Splendor', *M. sargentii*, 'Sentinel', 'Silver Moon', 'Sugar 'Tyme', 'White Angel', and 'Winter Gold'.

Consult MSU Extension Bulletin E-2177, "*Crabapples-A Selection Guide",* for more information.

Beech bark disease

Cause: This disease results from the invasion of a fungus into areas of bark that have been infested with beech scale, *Cryptococcus fagisuga*. At least two species of the *Nectria* fungus may be associated with the disease.

Hosts: European and American beech.

Insect lifecycle: The scale insect is yellow, oval, and about 0.5 to 1.0 mm long. Overwintering nymphs are covered with wooly, white strands of wax. They molt in spring and lay eggs in mid-summer. Eggs hatch from late summer to early winter, and crawlers migrate to other parts of the tree or are transported by wind to other beech trees. Once crawlers settle, they feed by inserting their stylets into the inner bark. The crawlers prefer areas of bark that are rough, such as cracks and crevices. Tiny injuries caused by feeding provide wounds for the fungus to enter.

Heavy infestations of beech scale on American beech. Closeup of beech scale colonies showing covering of white wax strands.

Scale insect
0.5 - 1.0 mm

0.5 mm

Beech bark disease - *continued*

Disease symptoms/signs: The fungus may occur in either its sexual or asexual stage. The sexual stage forms tiny, red to salmon-colored fruiting bodies on the trunk (perithecia). The asexual stage forms white cushions (sporodochia) of fruiting bodies that look similar to beech scale. Bark invaded by the fungus is killed. A reddish-brown fluid may ooze from dead spots in the trunk. Beech scale colonies can't live where the bark has been infected by the fungus and disappears from those areas. Foliage on branches above killed bark may become sparse and chlorotic, wilt suddenly and turn brown, or show no symptoms.

Heavily infested tree trunks look nearly white due to crusts of scale.

Beech bark disease - *continued*

Management: Left untreated, the disease may be fatal. Eliminating the scale insects controls the disease. Look for beginning scale infestations on the trunk of large trees, often near branch stubs or other rough areas. Remove scale insects from the lower part of the tree by brushing with a soft brush or by using water from a high-pressure nozzle. If horticultural oils are used, apply them only when the tree is dormant. Consult your local Extension agent for current insecticide recommendations and application times. Avoid moving beech logs or firewood from infested stands to uninfested areas from late summer to early winter (beech scale crawler stage) to help stop the disease's spread.

Beech blight aphid feeds on twigs and small branches of beech and may be confused with beech scale.

Black spot

Cause: *Diplocarpon rosae* (fungus)
Host: Roses

Symptoms: This fungal disease gets its common name from the symptoms produced on the leaves. Infected leaves drop off. Defoliation is worse in hot, humid weather. Leaf petioles, twigs, and canes may also be infected.

How it's spread: Splashing rain spreads the spores.

Management: At least seven hours of continuous leaf wetness with temperatures above 68°F are needed for spore germination. Use trickle irrigation or water early in the day to allow roses to dry quickly. Plant the roses in sunny locations with good air circulation. Rake up and destroy infected leaves; prune out infected canes before new growth starts in spring. Choose resistant cultivars where possible. Roses vary widely in their susceptibility to black spot; many hybrid teas, particularly yellow and orange roses, are particularly susceptible to black spot.

Leaf symptoms, showing irregular black spots with fringed margins. Yellow halos develop as the disease symptoms progress.

Black spot - *continued*

Although black spot isn't fatal, the disease can defoliate and weaken susceptible cultivars. Several fungicides are labeled for control.

Resistance: Roses reported resistant to black spot include: *Rosa wichuriana*, *R. roxburgii* and some of the *R. rugosa* hybrids. Consult a current reference for a more complete listing of resistant cultivars and hybrids. Suggested reference for more detailed information on managing roses: *Healthy Roses: Environmentally Friendly Ways to Manage Pests and Disorders in Your Garden and Landscape.* M. L. Flint, and J. F. Karlik. 2000. Oakland: University of California ANR Publication 21589.

Symptoms of black spot begin on the lower leaves and progress upward; the fungus overwinters on infected leaves and canes.

Botryosphaeria canker

Cause: *Botryosphaeria dothidea* (fungus)
Hosts: Many woody plants, including redbud, rhododendron, crabapples and dogwoods.

Symptoms: This fungus causes cankers and branch dieback. Cankers, which may take a year or more to develop, are visible as sunken, brown-to-black areas on infected branches (top right photo). As branches are girdled by the canker's spread, leaves wilt and die but remain attached to the branch (bottom right photo). Small, pimple-like fruiting bodies (pycnidia) may be visible in the area of the canker.

How it's spread: Drought-stressed plants are much more susceptible to this disease. This fungus frequently enters and infects through wounds.

Management: Keep plants well watered during droughts. Affected branches may be pruned out. Many fungal cankers look similar; confirm your field diagnosis by sending a sample to MSU Diagnostic Services.

Crown gall

Galls, shown here on euonymus, can range in size from about pea-sized to golf-ball size or larger. Galls start out spongy, and cream or green colored and become dark and woody with age.

Cause: *Agrobacterium tumefaciens* (bacterium)

Hosts: Creeping euonymus, rose, willow, and poplar are particularly susceptible. This bacterium produces tumor-like growths on plant crowns, branches, and roots.

Management: Remove and destroy severely affected plants. Galled parts can be pruned off; disinfest tools frequently when pruning. Avoid replanting susceptible plants in areas where infected plants have been removed. The bacterium enters through wounds and can persist in the soil for many years after infected plants are removed. A commercially-available biological control agent, *Agrobacterium radiobacter,* can be used as a dip or spray to treat bare root plants, such as roses, before planting.

Cytospora canker

Cause: *Cytospora kunzei* (fungus)
Hosts: The primary host is Colorado (blue) spruce. Other spruces, Douglas-fir, balsam fir, red and white pines, hemlock and larch, are infrequently attacked.

Symptoms: Wood under the cankered areas of the bark is dark and resin-soaked, compared with light-colored, healthy tissue.

How it's spread: The fungus overwinters in twig and branch cankers. Spores released from fruiting bodies during the growing season infect other branches, particularly at wound sites. Trees 15 to 20 years old (or older) suffering from drought, compaction, or poor site conditions are prime targets. Trees aren't usually killed outright, but the loss of major branches destroys the ornamental value of the tree.

White patches of resin ooze from cankered areas on the stem.

Cytospora canker - *continued*

Management: Improve tree vigor — a layer of mulch around the base retains moisture and helps protect lower branches from wounding by lawnmowers. Keep trees watered during drought periods. Prune out diseased branches when the foliage and wood is dry; clean tools with bleach or other disinfectant after cutting out diseased wood and before cutting healthy tissue.

Needles become off-color, turn purple, then brown and begin to drop off on one or more large branches, usually in the lower part of the tree.

Dutch elm disease

Cause: *Ceratocystis ulmi* (fungus)
Host: American, English and winged elms.

Symptoms: This disease may begin with yellowing and dieback on a single branch. As the infection spreads, wilting and yellowing of foliage, as well as dieback spreads throughout the crown. Dead leaves remain on the tree. Symptoms are more noticeable when the weather turns hot.

How it's spread: Drought-stressed trees are more susceptible. The fungus travels within the sapwood of the tree, causing brown streaks; it can be spread from infected trees to healthy ones through root grafts, and by bark beetles carrying spores.

Management: Verticillium wilt also affects elm trees,

Crown dieback symptoms - the fungus spreads to adjacent trees through roof grafts.

Brown streaks, which are visible in the sapwood of infected trees. The pathogen can remain alive in the streaked wood for extended periods of time.

Dutch elm disease - *continued*

producing brown streaks in the sapwood. Confirm your field diagnosis by sending a sample to MSU Diagnostic Services for positive identification of the fungus. Left untreated, the disease is usually fatal. Sever root grafts between diseased and healthy elms. Systemic fungicide injections in conjunction with sanitation pruning (The removal of large limbs at the first sign of the disease.) may be warranted for valuable specimens if symptoms have not progressed too far, but should only be attempted by a qualified arborist. Cut dead trees immediately and remove bark from any elm logs kept for firewood to prevent its use as a breeding site by elm bark beetles. Elms vary widely in their susceptibility. 'Regal', 'Urban' 'Sapporo Autumn Gold' and 'Pioneer' are among the hybrids developed that show resistance. Most of the Asian species of elm are resistant.

European elm bark beetle, (shown below) and the native elm bark beetle are vectors of the fungus that causes Dutch elm disease. The beetles deposit spores as they bore into cambium and sapwood and lay eggs in galleries that they create in the wood under the bark.

3 mm

Anthracnose -- Dogwood anthracnose

Cause: *Discula destructiva* (fungus)
Hosts: Flowering dogwood (*Cornus florida*) may be killed by this pathogen; Kousa dogwood (*Cornus kousa)* can serve as a carrier but rarely develops severe symptoms. Other dogwoods growing in Michigan are not affected.

Symptoms: Tan spots, sometimes with purple margins, appear on leaves and necrotic areas on leaf margins or veins. Lower leaves are affected first. Infected leaves may persist on the tree in the fall. (See photo at right).

How it's spread: Cool, wet weather in the spring or fall favors the development of this fungal disease. Spores produced from fruiting bodies on infected leaves and twigs spread by splashing rain to healthy tissue and nearby trees. Extensive twig dieback leads to the development of watersprouts. Infected watersprouts allow the fungus to spread into the main trunk and branches. The cankers eventually girdle the tree and kill it.

Dogwood anthracnose - *continued*

Management: There is no natural resistance to this disease. Avoid planting imported dogwoods near native dogwood stands. Although not all imported dogwoods are infected, early infections are difficult to detect and the disease is hard to manage once it spreads into a forest. Sanitation, i.e. pruning off and destroying dead twigs, removing watersprouts, and raking up fallen leaves is important. Plant trees in sunny exposures with good air circulation to allow quick drying of foliage. Avoid heavy applications of nitrogen fertilizers that encourage succulent growth. Maintain tree vigor through mulching and watering during dry periods.

Twig of flowering dogwood infected with dogwood anthracnose fungus. Raised, brown spots are fruiting bodies (acervuli) containing the spores and can be seen with a hand lens. Look at the second node back from the tip on the smallest terminal twigs for the fruiting bodies.

Extensive twig dieback leads to formation of epicormic shoots.

Fire blight

Cause: *Erwinia amylovora* (bacterium)
Hosts: Apple, crabapple, hawthorn, pear, cotoneaster, mountain ash, spirea, and flowering quince.

Symptoms: Major symptoms of fire blight appear during warm, moist weather in late spring; however, larger cankered limbs may not die back until dry weather during mid-summer. Milky-white to amber droplets of bacterial ooze may exude from infected plant parts. Cambial tissue is killed in the region of the canker and will be brown or black instead of green. Bark in cankered areas is darker than surrounding tissue and may appear sunken.

Branches appear as if scorched by fire; branch tips curve downward in a characteristic shepherd's crook.

How it's spread: The bacteria overwinter in live tissue around the margins of fire blight cankers. Once temperatures are above 65°F, bacteria resume growth, and the disease can spread rapidly. Insects pollinating blossoms, rain splash, or infested pruning tools can all serve as means of spreading the bacteria. Succulent, rapidly growing plant tissues provide an ideal medium for infection.

Fire blight - *continued*

Serious fire blight infections requiring major amounts of pruning are best undertaken during the dormant season so that bacteria aren't spread. Make pruning cuts 10 to 12 inches below infected areas.

Infection can take place through natural plant openings such as lenticels or wounds.

Management: Choose resistant cultivars or non-susceptible plants as replacements. For managing fire blight in existing plantings where replacement is not an option, limit applications of nitrogen fertilizer and heavy amounts of pruning, which encourage the development of succulent growth. **Never prune when branches or foliage are wet. If minor amounts of infection are present, these branches can be pruned out during the growing season.** Disinfest pruning tools between cuts with 10 percent household bleach. Disinfesting tools is not required during the dormant season. Douglas Chapman, director of Dow Gardens, has provided a list of fire blight-

Fire blight - *continued*

resistant crabapples based on observations over many years at Dow Gardens in Midland, Michigan. His list includes the following crabapples: 'Adams,' 'Beverly,' 'Bob White,' 'Camelot,' 'Candied Apple,' 'Centurion,' 'Donald Wyman,' *Malus floribunda*, 'Golden Raindrops,' 'Harvest Gold,' 'Henningii,' 'Indian Magic,' 'Indian Summer,' 'Jewelberry,' 'Mary Potter,' 'Molten Lava,' 'Ormiston Roy,' 'Prairifire,' 'Professor Sprenger,' 'Silver Moon,' 'Strawberry Parfait,' 'Sugar Tyme,' 'White Angel,' 'Winter Gold,' M. *zumi* var. *calocarpa*, 'Red Jewel,' 'Ruby Luster,' and 'Sentinel.' The University of Pennsylvania lists the following species and cultivars of pyracantha, cotoneaster and hawthorn as resistant to fire blight: **Pyracantha** 'Mojave', 'Navaho', 'Teton', and 'Shawnee' **Cotoneaster** *Cotoneaster amoenus, C. adpressus, C. dammeri* var. *radicans, C. microphyllus, C. praecox, and C. zabelii* **Hawthorn** *(Crataegus) C. arnoldiana, C. coccinea, C. crus-galli, C. douglasii, C. phaenopyrum, C.prunifolia, C. punctata* 'Ohio Pioneer', *C. viridis* 'Winter King.' Resistance to fire blight may not hold up over time or across locations. Strains of *Erwinia amylovora*, the bacterium responsible for causing fire blight, vary in virulence. Remember that resistant does not mean immune. Even when using resistant cultivars, it a good idea to **avoid overcrowding plantings or plant-ing in locations where air circulation is poor**. Both of these conditions increase humidity and create more favorable conditions for development of fire blight.

Oak wilt

Cause: *Ceratocystis fagacearum* (fungus)
Hosts: Oaks in the red and black group are the most susceptible; white oaks are less susceptible.

Symptoms: Trees in the red and black oak group undergo wilting and rapid death within a few weeks. Those in the white oak group usually experience the death of a few branches and may live for several years after infection. Water-stressed trees can show symptoms within a week of infection. Symptoms commonly develop in July but may be earlier or later depending on the amounts of rainfall.

How it's spread: This fungus invades the vascular system of oaks. Oak wilt is transmitted by picnic

Infected leaves wilt rapidly, turn brown around the edges of the leaves and usually remain attached to the tree. Browning begins at the leaf tip and spreads downward.

Brown streaking is visible in the sapwood of oaks infected by oak wilt, but the amount can be quite variable.

Oak wilt - *continued*

beetles (Nitidulidae), which carry spores from infected trees to wounds on healthy trees. Healthy trees may also be infected via root grafts with infected trees.

Management: Positive identification of this disease should be confirmed by sending twig samples to MSU Diagnostic Services. Samples must be from live branches (green or white tissue under the bark) not dead branches (brown or black tissue under the bark). Collect 3 twigs (at least 1 inch in diameter and 6 inches in length) from 3 different branches with wilting leaves.

Wilt symptoms usually begin in the upper branches of the tree and progress downward.

Grafts between infected and healthy trees should be mechanically severed. Avoid pruning until the dormant season. If pruning or wounding during the growing season becomes necessary, wounds should be sealed immediately with shellac or a water-based sealer. Red oaks infected with wilt cannot be saved. White oaks with less than 30 percent infection may benefit from fungicide injection by qualified arborists. For more detailed information on oak wilt and its management, see *Oak Wilt in Michigan*, Extension bulletin E-2764.

Juniper tip blight

Cause: *Phomopsis juniperovora,*and *Kabatina juniperi* (fungi)

Hosts: Juniper and rarely arborvitae, cryptomeria and chamaecyparis are susceptible to infection by these fungi. Susceptibility varies widely among species and cultivars.

Symptoms: Both fungi produce similar symptoms; time of symptom appearance differs.

Phomopsis infections begin at or near the branch tips of new growth and progress down the stem toward the older growth. Branch tips of infected new growth turn light green, then brown, then ash-gray. New fruiting bodies (pycnidia) can form within 3 to 4 weeks after infection.

Phomopsis tip blight: This fungus overwinters in small black fruiting bodies (~0.5 mm in diameter) on dead stems and needles infected the previous year. Spores are released during warm, wet weather and spread primarily through rain splash and overhead irrigation. Symptoms are common during wet, spring weather but may be present whenever new growth is present.

Kabatina tip blight: Infection occurs in fall, but symptoms don't appear until early spring. *Kabatina* infects through

Juniper tip blight - *continued*

wounds. Branch tips turn dull green then reddish-brown or yellow. Black fruiting bodies appear in small ash-gray lesions at the bases of the dead tips. Dieback occurs only in early spring. Juniper tips that have died from drought, dog urine or winter injury do not contain pycnidia and fade gradually from brown to green instead of having a sharp line dividing the dead and live tissue.

How it's spread: Spores can be spread by rain or infested pruning tools.

Management: Send a sample to MSU Diagnostic Services. Accurate diagnosis is made by looking at differences in spores. In general, avoid pruning when foliage is wet; avoid shearing or excessive wounding. When pruning out diseased plant tissue, disinfest pruning tools. Water early in the day to allow foliage to dry before nightfall. Avoid excessive fertilization, as it promotes succulent new growth. When installing new plantings, allow enough space between plants for good air circulation. Treatment timing and fungicide recommendations vary depending on which fungus is present.

Resources for additional information: Ohio State University Extension Factsheet, *Phomopsis and Kabatina Tip Blights of Junipers*, HYG-3056-96 online: http://ohioline.osu.edu/hyg-fact/3000/3056.html.

BP-29 *Juniper Tip Blights* Purdue University Cooperative Extension Service West Lafayette, IN 47907 online: http://www.agcom.purdue.edu/AgCom/Pubs/BP/BP-29.html.

Phytophthora root and crown rot, top dieback

Cause: *Phytophthora* spp., soilborne plant pathogens that belong to the group of fungi known as water molds.

Hosts: Azaleas and rhododendrons and Frasier fir are among the most susceptible. A partial list of other hosts includes: arborvitae, boxwood, cotoneaster, dogwood, elm, lilac, honeylocust, juniper, maple, magnolia, oak, pine, privet and yew.

Symptoms: Both aerial plant tissues and roots may be infected. Symptoms include wilting foliage and brown, rotted roots. Branches that have been invaded and girdled by the fungus wilt and die back. The diseased wood at the base of the branch near the soil line turns brown.

Wilting and dying foliage due to phytopthora root rot

Dieback of rhododendron branch due to stem infection by *Phytophthora* sp.

Phytophthora root and crown rot, top dieback - *continued*

How it's spread: Infection of plant stems and leaf petioles (see photos) may develop when the fungus is splashed onto aerial plant parts. Spores that develop on infected stems and petioles may be washed down to infect roots.

Management: Confirm your field diagnosis by sending in a sample to MSU Diagnostic Services for positive identification of the fungus. Avoid overhead watering or wetting the foliage of susceptible plants. Plants weakened by drought stress or planted in wet soils are more susceptible to infection by *Phytophthora* spp. Fungicides are not effective if plants have already been infected; remove and destroy infected plants. Susceptible plants growing in close proximity to infected ones should be treated promptly with a preventative fungicide.

This lilac is infected with the *Phytophthora* fungus; note the junction of diseased and healthy wood where the stem has been girdled.

Powdery mildews

Cause: Several different genera of fungi.
Hosts: *Sphaerotheca pannosa* var. *rosae,* which causes powdery mildew on roses, and *Microsphaera syringae* which affects lilac, are host specific. Some species of powdery mildew, such as the *Microsphaera penicillata* complex, may affect a wide range of ornamental trees and shrubs.

Symptoms: White, powdery coating on leaves, distorted or stunted foliage, shoots, flowers or fruit, chlorosis, browning and premature death of leaves, and slower growth are all symptoms of infection by powdery mildew.

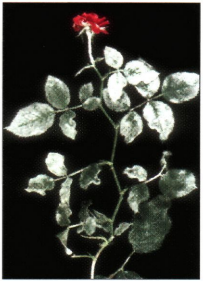
How it's spread: The mildews that affect roses and hawthorns overwinter in buds and infect new growth, but many mildews survive winter in special fruiting structures and release spores from them the following season. Spores travel on air currents to infect susceptible host plants.

Powdery mildew on lilac. The dark patches contain cleistothecia, fruiting structures that survive overwinter.

Powdery mildews - *continued*

Rain inhibits spore germination, but high humidity may make the disease more severe. Dry weather that is cool at night and warm during the day favors the development of powdery mildew.

Management: Powdery mildews that overwinter in buds may disfigure or prematurely kill new growth. Fungicides may be needed to manage them. Powdery mildews appearing on plants late in the season may be considered cosmetic; and generally do not require fungicides. Rake up and discard infected leaves to reduce the amount of fungus overwintering on leaf litter. Avoid practices that encourage succulent growth, such as heavy fertilization, and excessive pruning. Avoid overcrowding plants. Plants in shaded areas may be more prone to mildew. Avoid overhead watering in late afternoon or evening.



The fungal mat of white mycelium on aerial plant parts (shown here on oak and rose) has a powdery appearance that gives the disease its common name.

Rhizosphaera needlecast

Cause: *Rhizosphaera kalkhoffii* (fungus)
Hosts: Colorado blue spruce is the primary host. Norway spruce is resistant. Other spruces and pines are infrequently attacked.

Symptoms/signs: With a hand lens, you can see rows of black specks on the needles, where the pycnidia have emerged through the stomates of the needles. These black fruiting bodies are diagnostic of infection by *Rhizosphaera*. Healthy needles have white stomates.

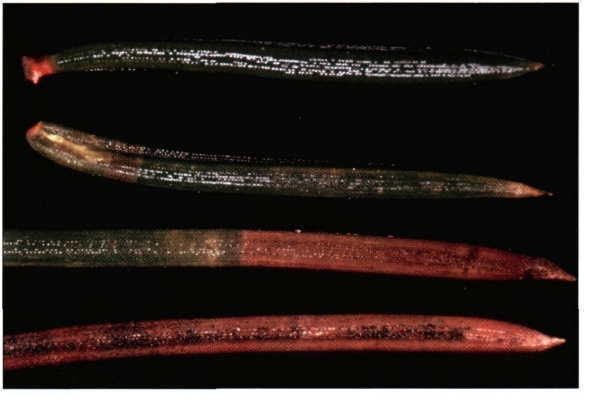
How it's spread: The fungus lives inside the needle tissue, producing black fruiting structures (pycnidia) that emerge through the stomates (pores) of the needle. Spores are released throughout the growing season during wet weather.

Symptoms usually appear in the lower part of the tree first and progress upward. Older inner needles show symptoms first. Needles may first develop yellow or red speckles or blotches before turning brown or purple. Needles drop off the tree.

Rhizosphaera needlecast - *continued*

Most infection occurs on mature needles in May and June during wet weather.

Management: Don't prune trees when foliage is wet. Disinfest tools after pruning diseased branches. Improve air circulation through pruning and proper plant spacing. Preventative fungicide applications when needles are half grown and again when fully grown may help if the disease isn't too severe.



Healthy stomates (top) appear white; pycnidia emerging through the stomates (lower needle) cause them to look black.

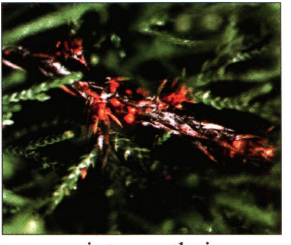
Cedar–apple rust, *Gymnosporangium juniperi-virginianae*, Cedar-hawthorn-rust, *G. globosum* Cedar-quince rust, *G. clavipes*

Hosts: These fungi require two different hosts to complete their development: an evergreen host (mainly junipers) and a rosaceous host.

Rosaceous hosts of rusts		
Cedar apple	**Cedar hawthorn**	**Cedar quince**
apple	apple	apple
crabapple	crabapple	crabapple
	hawthorn	hawthorn
	quince	quince
	mountain ash	mountain ash
	amelanchier	amelanchier
		cotoneaster

Symptoms on junipers

Gelatinous telia on junipers: (left) Cedar apple rust galls on twig; (right) Small galls of cedar-quince rust on twig.



How it's spread: These rusts overwinter on their evergreen hosts and produce jelly-like masses of orange telia from perennial galls during warm, wet weather in spring.

Cedar–apple rust, Cedar-hawthorn-rust, Cedar-quince rust - *continued*

Telia give rise to a different type of airborne spore that infects members of the rose family.

Symptoms on rosaceous hosts

None of these rusts kill their hosts, but cedar quince rust is the most disfiguring, producing not only leaf spots, but deformed fruits and petioles and stem galls. Cedar apple and cedar hawthorn rusts produce similar rusty orange leafspot symptoms and premature leaf drop. 'Cluster cups' form on backs of leaves and form spores that are carried on the wind and infect only junipers.

Management: Galls on junipers can be pruned off and destroyed before spore horns develop, but usually, only rosaceous hosts need protective fungicides. Apply labeled fungicides to broadleaf hosts as orange telial horns are first visible on juniper and repeat at several week intervals. Select resistant cultivars where possible when making new or replacement plantings.

Cause: Anthracnose refers to a symptom rather than a specific fungus.

Hosts: Different fungi produce anthracnose on specific host plants, as shown in the table on pages 86-87. Many plant diseases and weather stress cause similar symptoms. Don't rely on symptoms alone. Confirm your diagnosis at by sending a sample to MSU Diagnostic Services, where microscopic identification of spores is used for a positive I.D.

Symptoms: In general, anthracnose symptoms are worse after cool, wet springs. Spores have an extended opportunity to wash from branch and twig cankers to new leaves and shoots.

Sycamore anthracnose

Sycamore leaves with anthracnose develop brown lesions that begin along the leaf veins. Lesions enlarge and coalesce as infection progresses. Witches' brooms develop after repeated infection and dieback of twigs. Cankers may develop on twigs. The amount of defoliation depends on the severity of the infection.

Anthracnose symptoms on white oak in spring: Anthracnose on oak usually occurs in the lower crown.

Compare with oak wilt: The early symptoms of oak wilt may appear similar, but appear in July and begin in the upper part of the tree.

Ash anthracnose symptoms.

Management: Sanitation is important in managing anthracnose. Rake up and destroy fallen leaves to reduce source of inoculum. Remove diseased and dead wood and prune trees to improve air drainage. Fungicides are usually not needed, but fertilization may help trees that are heavily defoliated.

Symptoms of anthracnose on maple.

Host	Sexual (S) Asexual (A) stages	Plant parts affected/ symptoms	Susceptibility/ resistance	Conditions favorable for disease
Oak	*Apiognoma quercina (S) Discula quercina (A)*	(A) Leaves and new shoots shrivel or turn brown; leaves develop small brown spots or lesions near veins, twig dieback before budbreak in spring. (S) Overwinters on fallen leaves.	Most oaks. White and bur oaks are the most susceptible.	Wet weather in spring with temps in 64-82°F range.
Sycamore	*Apiognoma veneta (S) Discula platani (A)*	(S) overwinters on fallen leaves. (A) overwinters on infected twigs and bark- infects buds, new shoots, leaves and 1 yr. old twigs. Leaf lesions develop near veins. Chronic twig infections produce witches' brooms.	Sycamore and planetree are susceptible.	61-68° F + wet weather favors leaf infection; mid-50's around bud break favors shoot blight. (A) produces secondary infections during growing season.

Table continues on next page.

Host	Sexual (S) Asexual (A) stages	Plant parts affected/ symptoms	Susceptibility/ resistance	Conditions favorable for disease
Ash	*Apiognoma errabunda*	Overwinters on infected twigs and leaf petioles. Water-soaked spots or brown blotches on new shoots and leaves; small oval-shaped cankers on twigs.	Green ash is more resistant than other ash species.	Repeating cycles of infection occur during wet weather
Maple	*Kabatiella apocrypta,* others	Young leaves and shoots shrivel, turn black. Older leaves develop lesions, usually near leaf veins	Norway, red, silver, Japanese, sugar maple, and boxelder are susceptible.	Cool, wet weather (50-55°F) in spring and/or summer.
Walnut	*Gnomonia leptostyla* (S) *Marssonia juglandis (A)*	(S) Overwinters on fallen leaves,rachises, husks. (A) Leaves develop small brown spots with yellow margins.	Black walnut, butternut	Initial infection in spring by spores from (S) transmitted by wind, rain; 75-79°F favors infection of leaves (A) produces repeating cycles of infection during wet weather.

Sphaeropsis tip blight

Cause: *Sphaeropsis sapinea*, formerly called Diplodia tip blight (fungus)

Hosts: Primarily two and three-needled pines such as Austrian, Scotch, red and ponderosa pines.

Symptoms

Closeup of pycnidia on needle. Pycnidia are small but visible at the base of dead needles when pulled from the needle sheath.

Pycnidium is less than 1mm in diameter.

Needles of diseased shoots are stunted and straw colored, and have patches of dried resin near the base.

Sphaeropsis tip blight - *continued*

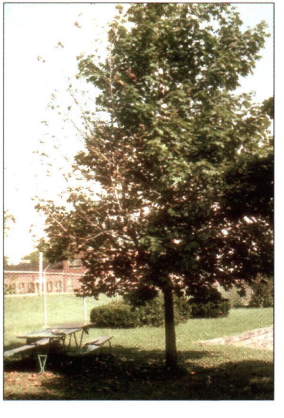
How it's spread: This disease is more severe on drought stressed trees. This fungus is an opportunistic pathogen that can live as an endophyte in healthy tissue and a saprophyte in dead tissues. The fungus overwinters as pycnidia on cones, diseased shoots and branch cankers, Spores ooze out of the pycnidia during wet periods and infect new needles in spring. The fungus can be spread on infested pruning tools.

Management: Replace severely infected trees with resistant species. Pruning may be done to remove infected twigs and cankered branches to improve the trees appearance, but since the fungus also overwinters on cones, it isn't likely that this practice will stop new infections. Prune only when the foliage is dry, and disinfest tools frequently during pruning or wait until late fall or winter to prune. Fungicides should be applied beginning when buds develop in spring until candles are fully expanded. Consult your local Extension agent for current recommendations. Avoid excessive fertilization. Keep trees watered during periods of drought, but avoid overhead irrigation.

Verticillium wilt

Cause: *Verticillium dahliae* (fungus)
Hosts: Maple is one of the most common hosts. Ash, barberry, buckeye, catalpa, cherry, dogwood, elderberry, elm, Kentucky coffee tree, lilac, linden, magnolia, maple, plum, redbud, rose, Russian olive, smoketree, spirea, sumac, viburnum, and weigela are some of the trees and shrubs susceptible to verticillium wilt.

Symptoms: Symptoms of chronic infection include: sudden wilting, leaf yellowing or scorching in a portion of the crown, often on one side. Foliar symptoms are most likely to appear during July and August, when plants are under water stress. Other symptoms of chronic infection include undersized foliage, poor growth, abnormally heavy seed set and twig and branch dieback. Plants may also become severely infected, wilt and collapse in a short period of time. Acutely infected plants may show: leaf curling or browning; foliage or areas between veins abnormally colored red or yellow; partial defoliation; wilting and branch dieback, often on only one branch or side of the tree or shrub. Verticillium wilt can also cause sudden death of a tree or shrub.



Verticillium wilt - *continued*

How it's spread: The fungus enters through wounds or natural openings in roots. Once inside the plant, it produces spores that move through water-conducting tissues. The fungus is found in soil and may persist in the ground for many years.

Olive-brown streaking in the wood is often found in maples infected with verticillium wilt. Colors vary in other hosts: black-to-brown or grayish green; some trees, such as ash, rarely show any streaking.

Management: Confirm your field diagnosis by sending a sample to MSU Diagnostic Services for positive identification. Fungicides are not effective against this disease. Avoid using a susceptible host as a replacement when replanting in an area where a plant has died of verticillium wilt.

Verticillium wilt - *continued*

Avoid using wood chip mulch made from trees or shrubs that died from verticillium wilt, as recent research suggests that the fungus may remain viable in wood chips for considerable periods of time. Trees and shrubs reported as resistant to verticillium wilt that could be considered as replacements include: arborvitae, fir, juniper, larch, pine, spruce, yew, birch, beech, boxwood, ginkgo, hawthorn, hickory, honeylocust, hophornbeam, katsura, mountain ash, bur and white oaks, pear, sweetgum, sycamore, walnut and willow.

Symptoms of verticillium wilt on elderberry in mid-summer; note wilting and dieback of branches.

Animal damage - deer

Deer feeding injury creates a ragged, rather than a smooth cut because deer lack upper front teeth. Piles of dark brown deer pellets (feces) may also be present in the vicinity of deer feeding. Buck rubs, produced by male deer rubbing the velvet from their antlers, occur in fall just before mating season. Small trees may be pushed over or bark shredded off the trunk in strips by bucks polishing their antlers and marking their territory.

Management: Protect plants by covering them with chicken wire, hardware cloth or shade cloth during the winter and early spring. If deer are really hungry, repellents won't be very effective. Repellents may need to be applied frequently due to weathering. Electric fencing can be an effective deterrent, but it is expensive and local ordinances may prohibit its use.

A browse line develops to mark the height of deer feeding injury.

Animal damage - meadow voles

Meadow voles (meadow mice) girdle plant roots and chew bark from around the base and trunks of trees and shrubs. Look for extensive runways through turfgrass leading from their burrows to woody plant material. Voles make surface runways (about 1.5 to 2 inches wide) through turfgrass, feed on the grass and leave piles of clippings and feces in the runways.

Small, grooved tooth marks in wood are indicative of vole injury.

animal damage - rabbits

Rabbits make sharp-angled cuts, neatly pruning off the ends of branches. They may also gnaw the bark off young trees or shrubs with thin, smooth bark. Look for piles of round, dry, brown fecal pellets near injured plant material.

Crabapples, burning bush, viburnums, yews and junipers are favored foods of both voles and rabbits during the winter months.

Voles and rabbits - *continued*

Management: Prune out badly damaged branches. If main stems are damaged, wait awhile before pruning to see if the injured tree or shrub will recover. Baited snap traps or rodenticides placed in runways can help control existing vole populations. Place baits in secure bait stations to prevent injury to non-target animals.

Remove groundcover or mulch from around the base of trees and shrubs (3 feet away) to reduce protective cover for voles. Wrap trunks with tree wrap or hardware cloth to protect against girdling. Remove tree wrap after weather warms.

To protect plants from rabbits, fencing should be at least two feet tall, with a one-inch mesh. Secure fencing with stakes or bury it a few inches in the ground to prevent rabbits going underneath. Repellents can be effective for limited periods of time, but may need to be reapplied frequently due to weathering.

Abiotic injury

Information on tolerant trees: For more detailed information about trees for urban environments tolerant of drought, salt, high pH and other conditions see the Urban Horticulture Institute website: http://www.hort.cornell.edu/department/faculty/bassuk/uhi/

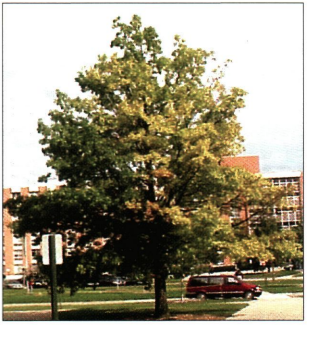
Abiotic injury - chlorosis

The term 'Chlorosis' refers to yellowing of the foliage and may have many different causes. Iron chlorosis is common on pin oaks, while chlorosis in red maples is commonly caused by a manganese deficiency. The availability of certain nutrients necessary for plant growth and development are limited by soil pH. In alkaline soil (pH >7.0), although these nutrients are present in the soil, they may not be in a form that can be utilized by the plant.

Red maple leaves below, show interveinal chlorosis caused by manganese deficiency.

Management: Before attempting any treatments, determine the cause of chlorosis. Test soil to determine pH. A foliar analysis can also help confirm a nutrient deficiency. Soil amendments to lower pH, such as elemental sulfur or ammonium sulfate, or injection of micronutrients may be effective. Success has been reported using fall soil injections of ferric ammonium citrate to treat chlorotic pin oaks. Waterlogged soils may also cause foliage to appear chlorotic, especially with evergreens.

Iron chlorosis symptoms on pin oak.



Abiotic injury - fall needle drop

It is normal for evergreens to lose their interior needles in the fall. Loss tends to be more pronounced during years with dry weather. It is not normal for needles to drop from the current year's growth, or to drop in the spring or summer. Check for another cause such as salt injury, a disease problem, frost, or drought if this occurs.

Abiotic injury - overmulching

Applying too much mulch around trees can restrict oxygen in the soil just like planting too deep. In heavy clay soils, thick layers of mulch may result in waterlogged soils. Mulch piled against the trunk may cause it to decay, allowing plant pathogens to enter and produce cankers. Mulch depths of 3" to 4" are adequate. Avoid piling mulch directly around the trunk. Taper the mulch depth around the trunk to about an inch or so.

Abiotic injury - improper planting depth

When planting, look for the root flare, and plant the ball with the root flare level with the ground. The kousa dogwood below declined over a period of several years before it died.

Below: The root flare was buried 5" down and topped with a layer of mulch. Be careful when uncovering roots of plants that have been buried for several years. Many roots have developed near the surface. These roots can be killed when uncovered. Adjusting planting depth is best done in spring after the weather settles to allow time for new root growth to develop and to allow the plant to adjust before the ground freezes.

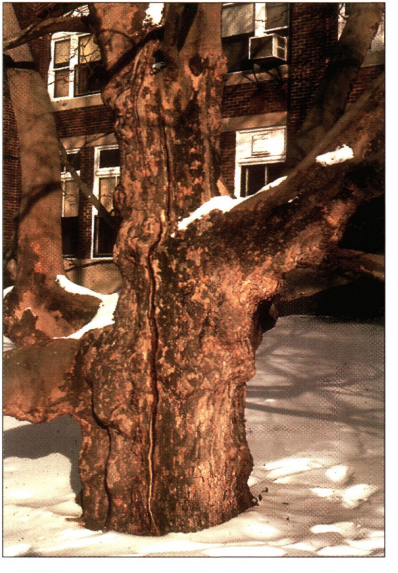
Improper planting depth - *continued*

Symptoms associated with planting too deep include wilting, stunted growth, chlorosis, dieback, early fall color, scorch, and the development of adventitious roots. Planting too deep restricts the amount of water and oxygen to the fine root systems, lowering the trees vitality. Trees planted too deep are also more subject to canker development and wind throw.

Above: Planting too shallow -- this yew was planted with part of the root ball sticking out of the ground, and the burlap and twine left on. Burlap should be removed if possible or at least cut off the top to allow water penetration into the root ball. Twine should be removed. The root ball should be just covered with soil.

Abiotic injury - frost and freeze

Frost cracks develop on the trunks of smooth barked trees due to differences in temperature. Winter sunlight heats the south and southwest sides of the tree during the day causing the bark to expand; when temperatures cool in the evening the bark contracts and splits.



Splits create entry points for fungi. Thin barked trees may also suffer from sunscald on the sides of the tree exposed to strong sunlight due to heating and dehydration of tender bark.

The reddish-brown dead tips on this spruce were caused by a frost as tender new growth was developing.

Frost and freeze injury - *continued*

Frost injury to leaves may be confused with anthracnose symptoms. (See page 83.) Anthracnose is caused by a fungus and will have a narrow and specific host range. Frost injury may be more severe in low areas, and you may find it on multiple species including surrounding perennials, annuals and weeds. Trees with frost damage may have leaves that have been completely killed, while other slightly younger or older leaves appear normal.

Injury on these birch leaves resulted from freezing temperatures as the leaves were developing. Injured tissue died, leaving holes as the undamaged parts of the leaf grew. Sometimes a ragged leaf margin results, as the undamaged leaf tissue expands.

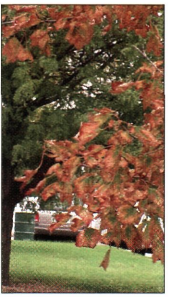
Little can be done about frost damage; plants tend to grow out of the injury with time. Trying to cover plants to protect them can actually result in more severe injury where the covering touches the plant.

Cupping and blackening of the tips and leaf margins that is wide-spread across sections of the tree are signs of frost.

Abiotic injury - scorch and drought

Leaves of trees suffering from scorch die along the leaf margin. Newly planted trees and those in areas where soil volume is limited (such as parking lots or along sidewalks) or there is intense heat reflection are most susceptible to scorch. Water is the most limiting factor for plant growth. The most critical period for drought stress is after transplanting. Well-established trees rarely die directly from drought injury.

Keep trees adequately watered during periods of drought. Mulch will help retain soil moisture. Irrigation bags may be useful for providing water in areas where irrigation is limited.



Abiotic injury - girdling wires and ropes

Ropes left around tree trunks, guy wires and hose from stakes may constrict growth or become embedded in the trunk or branch, causing it to become girdled. Reduced growth or dieback above the girdled point or a swollen appearance to the stem above the point of constriction may be evident.

Remove rope or wire if possible; sometimes injury is discovered too late for removal to be effective.

Abiotic injury - salt

De-icing salt (sodium chloride) can injure trees in several ways: direct contact of sodium chloride on the foliage from splashing and spray mist, and high levels of salt in the soil. High sodium levels in a plant can interfere with a number of metabolic processes including photosynthesis and protein synthesis. In areas with acute doses of de-icing salts, such as parking lots and sidewalks, plants may suffer osmotic stress, similar to 'fertilizer burn.'

Management: De-icing salts such as calcium chloride and calcium magnesium acetate (CMA) are more expensive than sodium chloride but much less damaging to plants. Protect susceptible plantings in high traffic areas with a screen of burlap-covered snowfence. Sodium is easily displaced from cation exchange sites in the soil. Applying gypsum or lime will supply other cations and speed the movement of sodium out of the soil. In salt prone areas, plant salt tolerant species and avoid salt sensitive species. For a list of salt tolerant trees see The Urban Horticulture Institute website. (See page 95.)

Severely salt-injured white pines along an expressway. Deciduous trees with chronic salt injury often develop extensive witches' brooms due to branch dieback.

Natural enemies

Natural enemies can suppress many insect pests in the landscape. In the landscape environment, use of beneficial insects and mites is based mainly on conserving natural populations, such as enhancing their environment by introducing nectar and pollen plants to provide supplemental food sources for beneficial insects, using selective pesticides, or making spot applications of pesticides. Using commercially-reared natural enemies may be helpful in the landscape, but the expense may be prohibitive.

A note of caution: Beneficial insects and mites may be more vulnerable to broad-spectrum insecticides (and some fungicides) than the pests they are targeted to control.

There are two main categories of natural enemies, predators and parasitoids.

Predators consume many prey in a lifetime, and tend to be larger and stronger than their prey. They may feed on many types of prey.

Parasitoids live inside their host or are attached to the outside of the host's body. Only the immature stage feeds on the host, and kills only one individual host. They may be much smaller than their host. The parasitoid is typically a specialist, that attacks only one or a few closely related species of host. They tend to be good at seeking out their host, and have high reproductive rates and short generation times.

Natural enemies - *continued*

Resources for more information: *Biological Control of Insect Pests in Forested Ecosystems: A Manual for Foresters, Christmas Tree Growers and Landscapers.* Deborah G. McCullough et al. Michigan State University. Extension Bulletin E-2679.

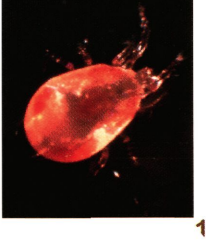
Biological Control of Insects and Mites: An Introduction to Beneficial Natural Enemies and Their Use in Pest Management. Daniel Mahr and Nino M. Ridgeway NCR481.

Midwest Biological Control News website: http://www.entomology.wisc.edu/ mbcn/mbcn.html

Natural enemies -- Predatory mites

Predatory mites are similar in size and shape to pest species but are faster moving. The phytoseiid mite *Phytoseiulus persimilis*, (below left) is non-native and is used commercially for biological control of spider mites adults and eggs under greenhouse conditions. Other native species in this family (Phytoseiidae) feed on eriophyid mites and spider mites in the landscape, such as the *Amblysius fallicis* shown at right.

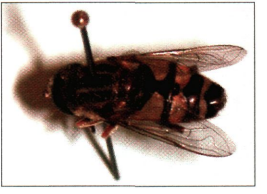
The size of the mite is less than 0.5 mm.



Natural enemies -- Predators

Predatory flies: The most important families of predatory flies are Syrphids and Cecidomiids.

Syrphid fly adults feed on nectar. They are also called hover flies because they hover in the air. Adults are often mistaken for honeybees; but have only one pair of wings, compared with two pair for honeybees. Larvae are green to brown, sometimes bi-colored. They are important aphid predators and are often found in aphid colonies. Larvae are 5-10 mm long. 5 mm



Cecidomyiid larvae are small (2 to 3 mm long) legless, and bright orange in color. They feed on aphids and spider mites. They inject a paralyzing toxin into the aphid's leg joints then suck out the aphid's body contents through the thorax. When aphid populations are high, these predators may kill many more aphids (4 to 65 per day) than they can eat.

Bright orange cecidomiid larvae feeding on aphids. Only the larvae are predaceous. Adults are small, black delicate-looking midges.

3 mm

There are around 40 families of beetles that contain predatory insects. Two of the most important are the lady beetles and the ground beetles.

Lady beetles (both larvae and adults) are important predators of a number of soft-bodied insects and mites, including aphids, scales, and mealybugs. Lady beetle adults found in Michigan range in size from about 1 1/2 mm long for some of the small black lady beetles that feed on scales and spider mites to 4 to 8 mm for the more familiar orange or red lady beetles.

Left: adult multicolored Asian lady beetle feeding on European elm scale. Right: multicolored Asian lady beetle larva.

The multicolored Asian lady beetle, imported as early as 1916 for biological control of certain pest insects, has more recently earned a reputation as a 'pest' itself due to its tendency to overwinter in homes and other buildings. It is a prolific insect feeder during the growing season, and may be displacing native lady beetles. For more info about multicolored Asian lady beetles go to: http://www.msue.msu.edu/ipm/beetleBio.htm

The adult is 6 mm long.

6 mm

Beetles - *continued*

The twice-stabbed lady beetle, *Chilocorus kuwanae* (not shown) is small and black with two red spots. The larva is black and spiny. It was imported from Korea as a biological control for euonymus scale, and is widely established in the United States.

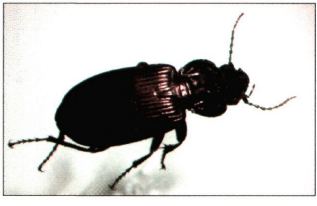
Adults and pupa of *Hyperaspis binotata*. These lady beetles were found feeding on magnolia scale. The larvae of these lady beetles and some others have waxy white coverings, which cause them to resemble mealybugs. These lady beetles are small; <4mm long. Lady beetles in related genera may feed on scales, adelgids, mites, aphids and/or mealybugs.

Lady beetle adults can be recognized by their broadly oval to nearly round shape, and short, clubbed antennae. Leaf beetles, which are plant feeders, have longer antennae without a club at the end. See references for more detailed information.

Above right: Larva and pupa of convergent lady beetle (*Hippodamia convergens*) in aphid colony. Above left: Adult *Coccinella* sp. These lady beetles feed on aphids.

Beetles - *continued*

Ground beetles - Adults are dark-colored with ridged wing covers (elytra), size range ~6 to 50 mm long. Their host range includes caterpillars, grubs, fly larvae and many adult insects. Larvae are also predaceous. The ground beetle below right, *Calosoma* sp. feeds on gypsy moth larvae.



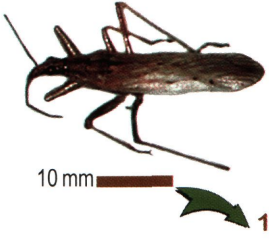
18mm

28 mm

Calosoma photo: Ronald F. Billings, Texas Forest Service, image 3226045, www.forestryimages.org

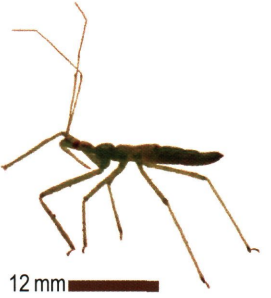
True bugs - There are around 21 different families of true bugs that contain predators. All true bugs have sucking mouthparts, formed into tubular beaks, which predators extend forward to stab their prey. Predators may also have enlarged front forelegs with spines for grasping prey. Only a few families are listed.

Damsel bug - These true bugs look similar to assassin bugs, but are dull colored (gray, brown or yellowish) and smaller-usually less than 10 mm long. They feed on aphids, mites, thrips, small caterpillars and leafhoppers.



10 mm

Beetles - *continued*



Assassin bugs - Both nymphs (shown here) and adults are predators on a variety of insects. They have long, narrow heads, and raptorial front legs for grasping prey. They vary from green to brown in color, and range in size from 12 to 36 mm long. They use their long beaks to stab prey, inject a digestive enzyme, and suck out the predigested body contents.

Spined soldier bugs - Both nymphs and adults of *Podisius maculiventris*, shown here, feed on caterpillars, beetle larvae, and other insects. This family of insects (Pentatomids) also contains plant feeders (look for downward-facing mouthparts for plant feeders).

Adult spined soldier bug 10 mm

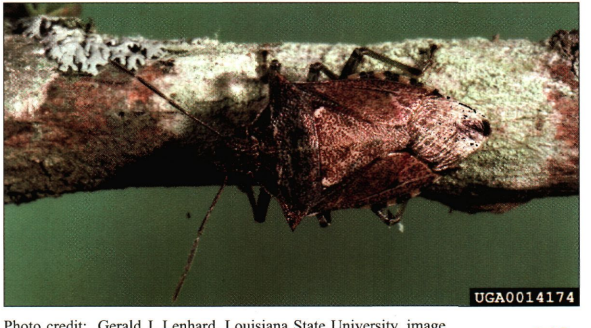
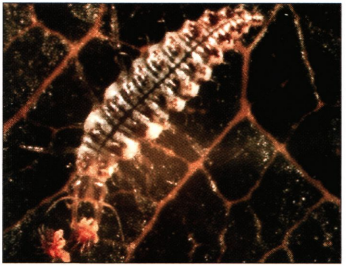


Photo credit: Gerald J. Lenhard, Louisiana State University, image 0014174, www.forestryimages.org

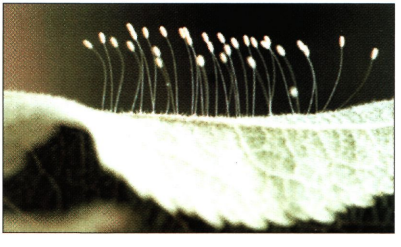
Natural enemies - lacewings

Green lacewing adults (right) are 10 to 12 mm long and feed primarily on nectar, pollen and aphid honeydew, but some species also eat insects.



15 mm

The larvae of lacewings (above left) are predaceous on soft-bodied insects such as aphids, thrips, scales and whiteflies. Larvae often carry the dead bodies of their victims on their backs. The eggs of green lacewings (below) are borne at the ends of long filaments.



Brown lacewing adults are smaller and brown in color, but otherwise similar to green lacewings. Eggs aren't borne on stalks. Larvae have similar food preferences but don't carry the remains of their victims on their backs.

Natural enemies - parasitoids

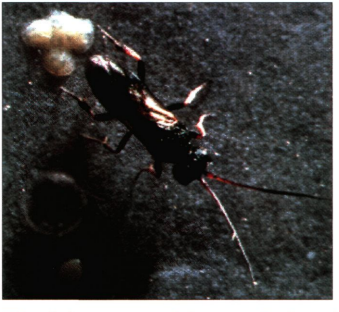
Parasitic wasps - There are over 40 families of parasitic wasps. A few commonly seen in the landscape are listed in this guide.

The oystershell scales with emergence holes in them have been parasitized by wasps. These tiny wasps (1 to 2 mm long) do not sting people. Several wasp families are known to parasitize scale insects.

Aphidiid wasps - These small (~3mm long or less) wasps are parasites of aphids. Female wasps lay only one egg inside each aphid. The wasp larva feeds and pupates inside the aphid, causing the aphid's body to become hardened and mummified. The adult emerges from the aphid body by cutting a hole through the aphid's hardened cuticle. Aphids parasitized by these wasps develop into swollen, tan or white mummies (at arrow).

Parasitoids - *continued*

Braconid wasps - This large family of wasps contains many important parasites of pest insects. Different wasp species attack particular insect stages. Eggs are laid inside the host. The larvae of some species develop inside the host, and some develop externally, creating small oval, white cocoons on the outside of the host's body.



Adult wasps are < 10 mm long, black, orange or yellow in color. This braconid wasp is parasitizing codling moth eggs.

10 mm

The **ichneumonid wasp** below is representative of another important family of parasitoid wasps. Size varies from ~ 3 mm to 38 mm. The ovipositor may be quite long, sometimes longer than the body. They have long antennae. Adults are usually black, brown, or tan, but some are more brightly colored. Common types of hosts include caterpillars, beetle larvae and the larvae of sawflies.

3 mm

Parasitoids - *continued*

Parasitic flies -
There are at least 12 families of flies that contain parasitoids.

Tachinid flies are the largest and most important group of insect parasitic flies. The larvae of all species are parasitic. Many are important natural enemies of major pests. Caterpillars, sawfly larvae and beetle larvae and adults are the usual hosts. Tachinid flies resemble house flies, but with bristles at the tips of their abdomens. They are usually gray, black, or striped. Eggs may be laid in or on the body of the host. Often caterpillars can be found with conspicuous white eggs glued to their bodies. Even if eggs are laid outside, the larvae develop internally in the host.

Scouting tips - using phenological indicators

Bloom times of specific 'indicator plants' are mentioned throughout the insect section as guidelines to use for scouting for vulnerable stages of pest insects. A phenological indicator plant provides a link between the occurrence of a distinct, easily recognizable biological event such as first bloom or full bloom of a flowering plant with a specific stage of insect development that occurs during the same time period.

Scouting is a costly and labor-intensive operation, requiring accurate tools to make hours invested in scouting more productive. Using indicator plants to time pest development indicators can improve the accuracy and cost-efficiency of scouting. Accurate timing of treatments can reduce the quantities of pesticide needed for control and allow for the effective use of narrow spectrum products and non-chemical controls.

Suggested reading: *Coincide-The Orton System of Pest Management.* 1989. Donald A. Orton with Thomas L. Green. 190 pages. Published by Dennis W. Jamieson, Labor of Love Conservatory, 468 S. President, Suite 103, Carol Stream, IL 60188.

Japanese tree lilac is blooming around the time that juniper scale crawlers are emerging.

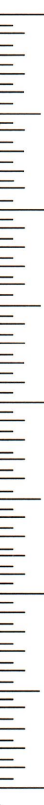
Distinguishing between caterpillars and sawfly larvae

Caterpillars have five or fewer pair of prolegs (fleshy outpouchings of tissue on the abdomen) and hooks called crochets at the base of the prolegs The adults are butterflies or moths.

Sawfly larvae have six or more pairs of prolegs and no crochets. The adults look similar to wasps.

Tools for scouting

- Hand lens -10x or 15x -To use a hand lens, place the lens directly in front of your eye and bring the sample you are examining towards the lens until the object comes into focus.
- Knife - good for cutting into stems or root tissue.
- Pruning shears- for taking samples – disinfest blades between samples to avoid spreading disease.
- A soil sampling tube, spade and/or trowel to sample soil or examine roots
- Plastic bags for samples/indelible marker- individually marking bags with information as the samples are collected makes it easier to keep information straight about what pests were found in particular locations
- Notebook or clipboard with record-keeping sheets. Plastic sheet protectors can be used to protect records and maps. Maps can also be laminated to prolong their useful life.



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