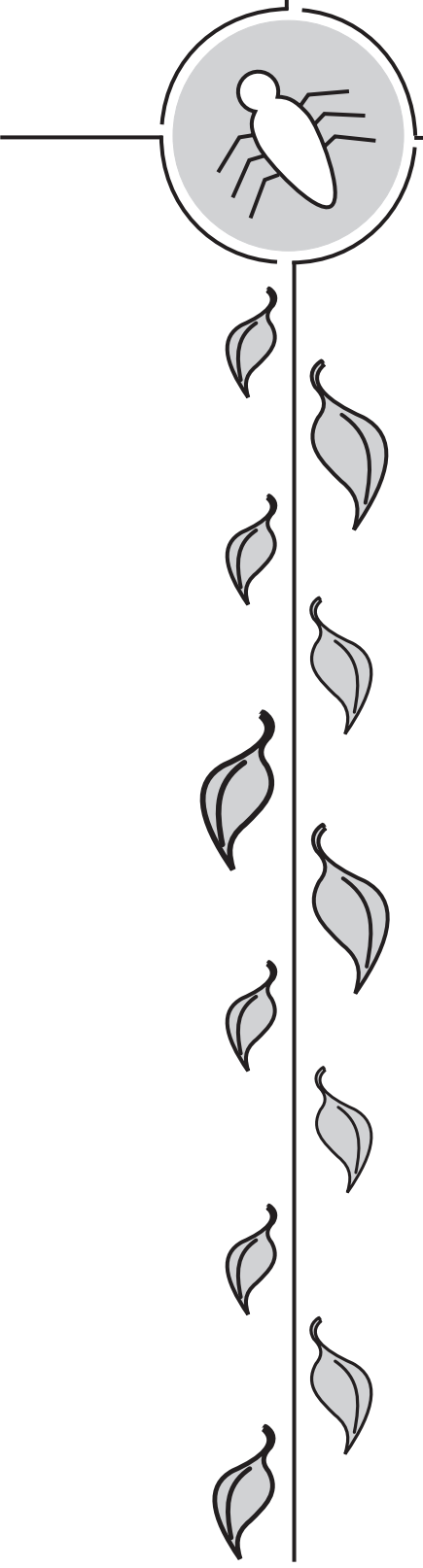
F-1192 (Revised)

Insect and Disease **Management Guide** for **Woody Plants** in North Dakota



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For more information on trees in North Dakota,
including photos of tree pests, see: www.ag.ndsu.edu/trees/

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Read and follow pesticide label directions, making certain to check instructions on how to apply, when to apply and important safety precautions. Before treating trees and shrubs, check the label for comments pertaining to plant sensitivity to the chemical. The pesticide use information in this guide is not intended for food-bearing trees and shrubs. Use of trade names in this publication does not constitute an endorsement or recommendation by NDSU or by the NDSU Extension Service over other similar products with the same active ingredient.

How to use this guide

This guide provides diagnostic aid and management practices for very common, frequently noticed and particularly problematic insects, mites and diseases of trees and shrubs in North Dakota. Many other pests and diseases are present on woody plants in North Dakota and tree and shrub owners may encounter them. The pesticide use information in this guide is not intended for food-bearing trees and shrubs.

The first steps in maintaining healthy woody plants are to identify the species of tree or shrub and know what is considered "normal" for that species. If the growth or form of a particular tree or shrub is not normal, then correctly diagnosing the cause is critical to proper management. Often, management means providing conditions that do not favor development of the problem, whether its origin is an insect, disease or environmental. When tree
and shrub owners know the identity of the host, they can use the "Host Index" (pages 10 and 11) to identify its common pests quickly. The pests are described in more detail and with management information on the page numbers listed in parentheses in the "Host Index." See the "Disease Control Products" list and "Insect/Mite Control Products" table at the end of this guide for common pesticide products.

Many of the serious insect and disease problems in North Dakota are often associated with stressed trees and shrubs. The text refers to the discussion "Maintaining Healthy Trees and Shrubs" (page 3)

Preventing Problems
by Maintaining Healthy Trees and Shrubs

Some pests, such as many of the wood-boring insects and canker-causing fungi, are opportunistic, becoming serious problems on trees and shrubs that are under considerable stress. Inadequate moisture, extremes in temperature, unfavorable soils, herbicide injury, mechanical injury and tree age are stress factors often associated with trees in the northern Great Plains. These factors and others, such as defoliating insects and diseases, often will predispose trees to opportunistic insects and diseases. This section deals primarily with trees in landscape settings, but the principles also apply to trees in conservation and natural settings.

Maintaining Healthy Trees and Shrubs

By learning which trees are in their landscapes, tree owners can become aware of the moisture, light, nutrient and other environmental needs of their trees. They can address these requirements to attain the healthiest trees possible. Conscientious tree owners already practice many measures to improve tree health to sustain vigorous, healthy-looking trees. Occasionally, these measures
need some minor adjustments to address particular pests that threaten specific trees. Since many insect pests and diseases attack only certain tree species, tree owners who know their trees can become aware of the pests that pose a threat. Providing prime environmental conditions reduces the likelihood that opportunistic insects and diseases will kill trees.

Reducing Stress in Newly Planted Trees and Shrubs

Trees and shrubs are very susceptible to opportunistic insects and diseases when they are recovering from the planting/transplanting process and becoming acclimated to new locations. In broadleaf trees, symptoms of planting/transplanting stress may include leaf wilting or rolling and browning of leaf margins, while conifers may show an overall gray-green discoloration of foliage and tip dieback of needles. All trees with transplant stress show reduced growth and may have sprouts (adventitious shoots) developing from the trunk and off the sides of large limbs. To reduce the susceptibility to such stress, select the right tree for a given location, use the appropriate planting technique, mulch, water, don't fertilize, and provide protection from physical injury and sunscald.

Select the Right Tree

Selecting trees and shrubs for planting in a particular site should include considerations of hardiness, moisture requirements, insect and disease resistance, mature size and freedom from insects and diseases at the time of purchase. Plants generally should be labeled for U.S. Department of Agriculture hardiness zone 4 in southern North Dakota and for zone 3 in northern North Dakota. Plants labeled for warmer (higher numbered) zones may develop dieback of branch tips if they survive the winter or may grow well for several years only to die in a year that exceeds their hardiness limits. Placing trees and shrubs where other environmental requirements, such as soil conditions, moisture, light and space, are proper will improve establishment and long-term resistance to opportunistic insects and diseases. Some plants have been selected specifically for resistance to important insects and diseases and should be used if a particular pest problem is known for the area. Trees and shrubs should not be purchased when they have poor form or

are infested with insects or diseased while in the nursery. If a homeowner desires a particular tree species, select the right location for that species. If a particular site needs trees, select species that thrive under the conditions at the site (e.g., willow and dogwood in wet areas, Russian-olive and caragana in alkaline areas or linden and arborvitae in shaded areas).

Planting Technique

Do not let tree roots dry out before, during or after the planting process. The planting hole can greatly affect the health of a newly planted/transplanted tree. Plant a tree so that the root crown is no more than 1 inch below the soil surface after settling. Holes should be dug at least two to three times wider than the root ball to provide for free growth of the roots. The sides of the hole should not be left glazed after digging. Roughen them to allow adequate movement of water and air to the roots and growth of roots out into surrounding soil. Before placing a tree or shrub in a hole, direct circling roots away from the root ball. If the circling roots are too large to redirect, cut them off with a sharp blade to prevent girdling of the plant years later. Many people feel that securing trees to stakes whenever they are planted always is necessary. This type of support is necessary usually only when a tree is tall, slow to recover, heavily foliaged or planted in a sandy site or playground. Most small trees and shrubs do not require staking
and will develop strong trunks faster if allowed
to move freely with the wind.

Mulch

Mulch placed over the soil surface above the tree or shrub root system helps conserve moisture, moderate soil temperature, and control weeds around trees and shrubs. Tree and shrub owners may use either organic or inorganic mulch.
Organic mulch may be composed of bark or wood chips, straw, partially decomposed leaves or other materials. These mulches decompose over time and should be replenished as needed. Organic mulch should be applied 3 to 4 inches deep, leaving a
4- to 6-inch mulch-free area around woody stems. Inorganic mulches include plastic, crushed rock, woven fabric and other materials. Crushed rock may impede trunk expansion. Solid plastic mulches may impede or prevent root development because they do not allow air or moisture to
move into or out of the soil from above. Do not
use mulch when the soil is poorly drained.

Water

Too much or too little water seriously stresses newly planted trees and shrubs. The site should
be thoroughly watered immediately after planting. Thereafter, monitor the soil regularly to prevent drying out. If rainfall is inadequate, the soil around the plant's roots should be watered deeply approximately every 10 to 14 days. If you are not sure if the soil is drying, dig down 3 to 4 inches next to the plant. Moist soil at that depth verifies the tree doesn't need watering at that time, while wet soil may indicate over watering. In particularly light soils or dry areas, consider a drip irrigation system. Avoid water that is high in salts when watering trees.

Fertilizer

Do not fertilize trees during the season when they are planted. Woody plants rarely need nutrients beyond those naturally occurring in the soil to remain healthy. If trees or shrubs appear to need fertilizer, apply only the amount needed for optimum growth and health. Too much fertilizer can increase tree and shrub susceptibility to certain insects and diseases. Nitrogen fertilizers should not be applied from July 1 to Sept. 15, since such applications may result in growth that does not harden off adequately prior to winter.

Pruning

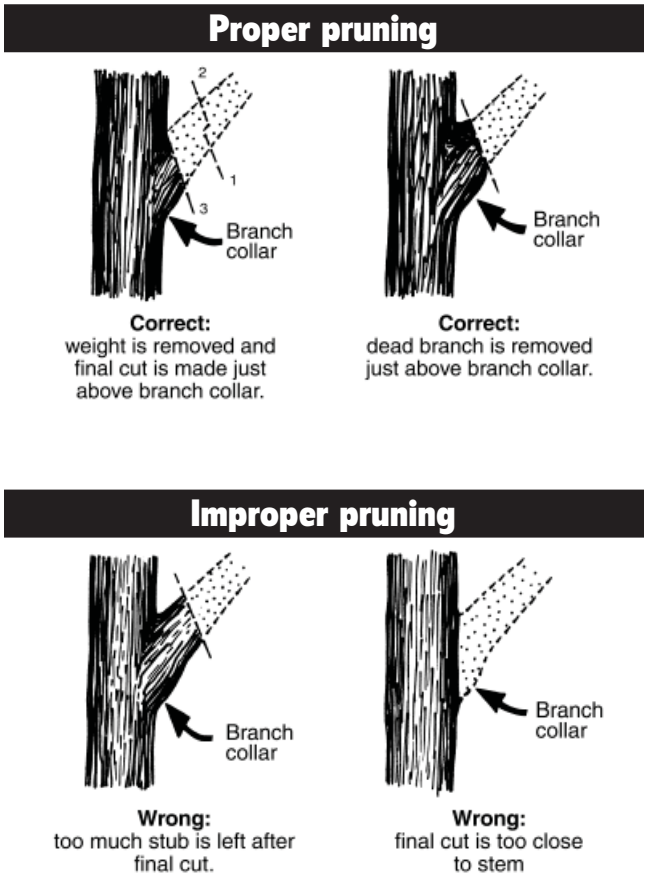
Tree limbs may be broken before or during planting, and improper pruning sometimes occurs prior to purchase. Broken limbs should be removed after the tree is planted with a cut made just outside of the branch collar (Figure 1).

Pruning to improve tree structure should be delayed until the tree has become established and no longer is showing symptoms of transplant stress. The adventitious shoots often associated with transplant stress usually do not contribute to tree structure and should be removed as soon as they develop. Asphalt-based wound treatments do not hinder pathogens' infection of the wound, and because they slow callus growth, they actually may favor infection. They also may be toxic to plant tissues.

Protecting Newly Planted Trees

Bark of young trees is very susceptible to natural and man-induced injuries. Injuries that lawn mowers and weed trimmers cause are common problems for landscape trees. Homeowners can place hardware cloth or tree guards around the base of trees to prevent bark injury that rodent feeding and lawn-care equipment cause. Tree wraps and white paint have been used to prevent injury from sunscald. Proper mulching decreases the need for weed cutting next to the trunk and reduces movement of potentially damaging machinery next to the tree.

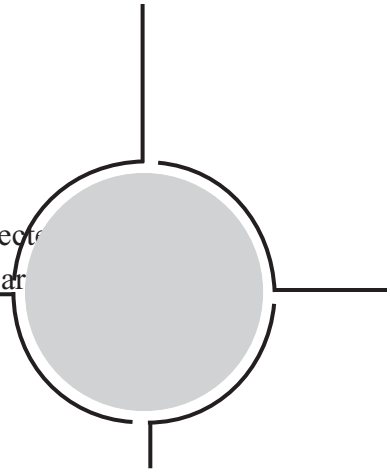
Figure 1. Proper and improper pruning techniques.



Maintaining Established Trees and Shrubs

As with all living things, trees and shrubs become

old and die. Established trees die at an unnecessarily early age when they are subject
a stressful environment. Identifying and mitigating stress factors can add many year
tree's life.



Water

Research has shown that many opportunistic insects and diseases cause more tree injury when trees lack adequate water; however, similar problems can develop when trees have too much water. Proper water amounts are especially important for building food reserves during early and midsummer and for building tissue moisture levels going into winter. Many tree roots are deeper in the soil than turf roots; therefore, trees should be watered for longer periods of time than turf alone. This allows the water to move through the turf and deeper into the soil. Generally, trees need to be watered less often than turf but require more water in a given area than turf during each watering. If the soil remains too wet, consider aerating the soil or improving subsurface drainage.

Avoid Tree Injury

Trees often are damaged by chemicals and lawn-care equipment, and during construction activities. Damage to roots from trenching, soil compaction, de-icing salts and herbicides may not become evident for several years after the incident occurred. To reduce injuries from herbicides, de-icing materials and other chemicals, carefully choose safe products and apply them cautiously. One herbicide that very commonly damages landscape trees is dicamba, which is an ingredient in several broadleaf control mixtures used in lawns; herbicides containing dicamba should not be applied over roots of trees. To avoid some physical injury to trees, notify construction and landscape maintenance people of tree-care priorities and use mulch to keep lawn mowers, weed whippers and other equipment a safe distance from the trees. Remove tree wraps and other materials that encircle limbs before they girdle branches and stems.

Remove Broken and Diseased Stems

Broken stems and branches should be removed from a tree as soon as possible (Figure 1). Pruning can remove some diseases, such as cytospora canker on spruce. Pruning to remove diseases should be done during dry periods and is best done during late winter after the hardest freeze,
but before buds begin to swell in the spring. If the tree species is susceptible to diseases that can be transmitted on pruning tools (e.g., fire blight), and the disease-causing organism is present, the tools should be cleaned properly between each cut.

Fertilization

Soil fertility seldom is a problem for established trees in North Dakota landscape plantings; however, there are exceptions. Trees and shrubs should be fertilized if they show symptoms of nutrient deficiency or produce inadequate growth after they are established. Soil or leaf tissue analyses may be useful in determining deficient nutrients. Certain nutrients may not be available to plants even though they are present in the soil. Yellowing (chlorosis) of leaves due to low iron avail-

ability is the most commonly diagnosed micronutrient deficiency of North Dakota trees. Too much fertilizer also can cause problems. Excess nitrogen fertilization has been proven to increase damage that certain insects and diseases cause on woody plants.

Monitor for Insects and Diseases

Insect and disease problems can cause stress that leads to increases in those or other pest problems. Finding and managing an insect or disease problem before it causes serious damage may increase the likelihood of plant survival and continued aesthetic performance. The Host Index can be helpful in identifying an unknown problem.

Rejuvenating Shrubs

To rejuvenate many decadent deciduous shrubs, cut them back 4 to 5 inches above the ground and allow new shoots to grow. This generally does not work for conifers and may result in more insect or disease problems in some deciduous shrub species (e.g., honeysuckle aphid on honeysuckle). Some flowering species require several years of growth to restore a full complement of flowers.

Removal of Declining/Hazardous Trees

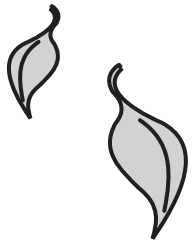
No one gains by having sick or ugly plants in the landscape. As with all living things, trees have a given life expectancy and that expectancy is shorter in the northern Great Plains than other areas. Declining trees may serve as reservoirs for various insect and disease problems. Large, old trees can become hazardous, threatening lives or property as they decline and decay. If tree owners can't mitigate the hazard, they should remove those trees. Also consider removing the tree if it no longer provides desired functions, such as beauty, shade or wind protection and cannot be restored to provide these functions.

■ Pest: **Aphids**

(*general*) family Aphididae

Host(s): Conifers and hardwoods. Many species of aphids are host specific, but more than one species can attack a given host. This makes species identification difficult, often requiring an aphid taxonomist.

Description/Biology: Small, soft-bodied insects with pear-shaped abdomens are typical. Aphids overwinter as eggs attached to foliage or twigs. Eggs hatch in early spring and the nymphs feed on twigs. The nymphs develop into asexual females that produce nymphs without mating. These nymphs develop into winged and wingless females that continue to reproduce asexually. As many as six generations occur annually. In late summer or early fall,



General Insect and Disease Management

Tree and shrub owners have many factors to consider when dealing with insect pests and diseases of woody plants. The most important factor is that woody plants have many defenses against insect pests and diseases, and usually are successful in defending themselves when they
are attacked. Further, no species of woody plants are without problems; many insect pests and diseases are easier to manage than other problems. Sometimes, insects and fungi are secondary; that is, they are present only on plants that other problems have damaged. Some problems may
be the result of insect or pathogen activity, but no sign of those organisms still may be visible by the time someone notices the damage. Also, not all insects or microorganisms associated with trees and shrubs cause problems; some are beneficial and even may be required for the plants to grow normally. Thus, do not place too great an emphasis on insects and pathogens as the cause of woody plant problems. Deal with them on a similar
level as other woody plant problems; spraying or removing plants often are ill-advised first choices that are not appropriate.

Insects and pathogens coexist with woody plants in their natural habitat. The amount of damage that pests cause can vary substantially. Conversely, the amount of damage an individual tree or plant can sustain and remain healthy also is highly variable. On the whole, the natural system is balanced so usually neither the woody plants nor the insects and pathogens are exterminated. However,
in a given situation, some woody plants may be damaged seriously or even killed. Also, when a change occurs in the natural system, such as when plants, insects or microbes enter new areas, the natural system may find a new balance. The changes may be subtle or imperceptible, or they may be catastrophic.

The relative health of woody plants and how well they provide their expected benefits can be manipulated to some extent. In the case of a plant health issue, evaluate what functions are expected of the plants, how the problem affects those functions, and whether management of the problem can retain or restore the expected function. The role, biology and effect of insects or diseases that may be involved should be included in evaluations. Correct diagnosis of the problem is critical
to proper treatment. Careful observation of how a problem developed, the pattern of occurrence of the problem, and the association of harmful factors with that development and occurrence can be very useful in diagnosing the cause of woody plant problems.

Limited information can be provided in this space; many more potential insect and disease problems exist than are included here. Many other resources contain additional information. Finally, professionals are available to help in diagnosis, evaluation and management of woody plant pest problems. These include NDSU Extension Service county agents, North Dakota Forest Service foresters, USDA Natural Resources Conservation Service district conservationists and foresters, local
arborists, nurseries, consultants, city foresters, the NDSU Diagnostic Laboratory, and NDSU Extension and research staff. Tree and shrub owners may need one or more of these sources of help to get the information to deal with the problem. However, consulting with local professionals first is best. Plant owners generally can obtain a satisfactory diagnosis and management plan with a little effort. However, because so many potential pest problems exist, and they may be intertwined into a mass
of other problems, satisfactory diagnosis or management of some situations sometimes can be very difficult or not possible.

Host Index

Host	Insect(s)/Mite(s)	Disease(s) and Disorders
Arborvitae	Fletcher scale (19), Spruce spider mite (25)	Winter injury (47)
Ash	Aphids (12), Ash bark beetles (12), Ash flower gall mite (12), Ash/lilac borer (13), Ash plant bug (13) Cankerworms (14, 15), Carpenterworm (15), European fruit lecanium scale (18), Fall webworms (19), Forest tent caterpillar (19), Redheaded ash borer (24)	Ash anthracnose (33), Ash rust (33), Ash yellows (34), Verticillium wilt (45)
Aspen	Fall webworm (19), Forest tent caterpillar (19), Leaf miners, Poplar borer (23)	Armillaria root rot, Melampsora leaf rust (41)
Birch	Birch leafminer, Bronze birch borer (14), Fall webworm (19), Forest tent caterpillar (19)	Melanconium canker
Boxelder	Boxelder erineum gall mite (14), Boxelder bug, Boxelder twig borer (14), Cankerworms (14,15), Cottony maple scale (16), Fall webworm (19)	Herbicide injury, Tubercularia canker (44)
Buckeye		Environmental leaf scorch (38)
Caragana	Blister beetles (13), Grasshoppers, Leafhoppers	Caragana canker, Septoria leaf spot
Chokecherry	Chokecherry midge (15), Chokecherry pocket gall mite (16), Eastern tent caterpillar (17), Fall webworm (19), Prairie tent caterpillar (24), Uglynest caterpillar (26)	Black knot (34), Brown rot (35), Leaf curl, Valsa canker (45), X-disease (47)
Cotoneaster	Oystershell scale (22), Pear slug sawfly (22)	Camarosporium canker, Fire blight (39)
Cottonwood	Cottonwood leaf beetle (16), Fall webworm (19), Leaf miners, Poplar borer (23), Forest tent caterpillar (19), Poplar bud gall mite (23), Poplar petiole gall aphid (23)	Melampsora leaf rust (41), Septoria leaf spot and canker of poplars (44), Venturia leaf and shoot blight (45), Wetwood (46)
Crabapple	Fall Webworm (19)	Apple scab (33), Black rot (35), Cedar-apple rust (36), Fire blight (39), Frogeye leaf spot – see Black rot (35), Powdery mildew (42)
Elm	Cankerworms (14,15), Carpenterworm (15), Cottony maple scale (16), Elm leaf beetle (17), Elm sawfly (17), European elm bark beetle (18), European elm scale (18), Forest tent caterpillar (19), Native elm bark beetle (21), Woolly elm aphid (26)	Botryodiplodia canker (35), Dutch elm disease (37), Elm black leaf spot (38), Elm wilt, Herbicide injury, Tubercularia canker (44), Verticillium wilt (45), Wetwood (46)
Hackberry	Hackberry nipplegall psyllid, Red-headed ash borer (24)	Hackberry witches's-broom
Hawthorn	Pear slug sawfly (22)	Cedar-apple rust (36), Environmental leaf scorch (38), Fire blight (39)
Honeylocust	Cottony maple scale (16), Honeylocust pod gall midge (20)	Tubercularia canker (44), Winter injury

Host Index

Host	Insect(s)/Mite(s)	Disease(s) and Disorders
Honeysuckle	Honeysuckle aphid (20)	Powdery mildew (42)
Juneberry	Woolly elm aphid (26)	Black leaf and witches'-broom, Cedar-apple rust (36)
Juniper (Cedar)	Fletcher scale (19), Spittlebugs, Spruce spider mite (25)	Cedar-apple rust (36), Kabatina tip blight
Lilac	Ash/lilac borer (13), Oystershell scale (22)	Gray mold (39), Lilac witches'-broom – see Ash yellows (34), Powdery mildew (42)
Linden	Cottony maple scale (16), Forest tent caterpillar (19)	Environmental leaf scorch (38)
Maple	Cottony maple scale (16), Fall webworm (19), Maple bladdergall mite (20)	Eutypella canker, Iron chlorosis (39), Sunscald, Winter injury
Mountain-ash	Pear slug sawfly (22)	Apple scab (33), Black rot canker (35), Fire blight (39), Sunscald
Oak	Cankerworms (14,15), Forest tent caterpillar (19), Numerous gall forming insects, Oak bullet gall wasp (21), Oak erineum gall mite – see Mites (21), Oak lace bug (21), Two-lined chestnut borer, Variable oakleaf caterpillar (26)	Oak anthracnose (41), Oak leaf blister (42), Oak leaf curl, Powdery mildew (42)
Pine	Introduced pine sawfly (20), Pine aphids, Pine moth (22), Pine needle scale (23), Spruce spider mite (25)	Diplodia tip blight (37), Red band (Dothistroma needle blight) (43), Sooty mold (44), Needle diseases, White pine blister rust, Western gall rust (46), Winter injury (47)
Plum	Chokecherry pocket gall mite (16)	Black knot (34), Brown rot (35), Phomopsis canker, Plum pockets (42), Powdery mildew (42), Shothole, Valsa canker (45)
Poplars	Carpenterworm (15), Cottonwood leaf beetle (16), Cottony maple scale (16), Fall webworm (19), Forest tent caterpillar (19), Poplar borer (23), Poplar bud gall mite (23), Poplar petiole gall aphid (23)	Marssonina leaf spot (40), Melampsora leaf rust (41), Septoria leaf spot and canker of poplars (44), Venturia leaf and shoot blight (45)
Rose	Aphids (12), Rose leaf miners, Spider mites (22)	Gray mold (39), Powdery mildew (42), Viruses
Russian-olive		Tubercularia canker (44), Phomopsis shoot blight
Spruce	Eastern spruce gall adelgid (16), Pine needle scale (23), Spruce budworm, Spruce needleminer (25), Spruce spider mites (25), Yellowheaded spruce sawfly (27)	Cytospora canker (36), Lirula needle blight (40), Rhizosphaera needlecast (43), Winter injury (47)
Viburnum	Cecidophyes sp. mite, Dogwood borer	
Willow	Black willow aphid – see Aphids (12)	Leaf rust, Venturia leaf and shoot blight (45)

the insects produce a sexual generation and these females deposit the overwintering eggs.

Damage/Symptoms: Aphids suck plant juices, causing discoloration on plant parts. Other symptoms include deformed plant parts (leaves and shoots) and reduced shoot growth. Damage often is minimal unless infestations are very severe and persistent for several years. Aphids secrete large amounts of honeydew, which can become overgrown with unsightly sooty mold. Honeydew causes problems when it lands on cars, picnic tables and sidewalks, causing them to become sticky and overgrown with sooty mold. Ants often tend aphids for their honeydew secretions.

Comments: A few aphids will not damage plants substantially. Natural predators often are present and will keep aphid populations at low levels. If an aphid population is becoming unacceptable, look to see if predators (ladybird beetles, lace wings, etc.) are present. If present, holding off on chemicals and allowing nature to take its course may be better. In some cases, a strong jet of water from a hose may be effective in reducing aphids to insignificant levels. If compelled to use pesticides, use an alternative product such as insecticidal soap to reduce the impact on beneficial insects. Many conventional insecticides, such as acephate, carbaryl, malathion and permethrin, are labeled for aphids on trees and shrubs. Professional applicators may inject acephate and other insecticides into the tree.

■ Pest: **Ash bark beetles**
(*Hylesinus* spp.) family Scolytidae

Host(s): Ash

Description/Biology: Small (1/8 inch), cylindrical, hard-bodied bark beetles with dense scales common on the front wings. When viewed from above, the thorax partly or completely hides the head. Adult beetles overwinter in hibernation chambers in the rough outer bark on the trunk of an ash tree. The insects produce one generation per year. The adults emerge in the spring, usually late May or early June, and excavate egg galleries in twigs and branches.
The eggs hatch into small, white, legless grubs with brown heads that form galleries parallel to the wood grain. Larvae pupate inside the galleries. Adults emerge from pupae in late summer and construct overwintering galleries. Some excavate egg galleries, but no one knows whether the resultant larvae survive the winter.

Damage/Symptoms: Attacks and kills small twigs and branches. Only the western ash bark beetle, H. californicus, is capable of killing live trees by boring into the boles of the trees.

Comments: Remove dead branches and trees from the vicinity to prevent movement of the beetles to healthy trees. See "Maintaining Healthy Trees and Shrubs."

■ Pest: **Ash flower gall mite**
(***Aceria flainiflora***) family Eriophyidae

Host(s): Ash

Description/Biology: The mites overwinter as fertile females beneath bud scales or in crevices of the bark. The females move to the male flowers in the spring, where they lay their eggs. Eriophyid mites are very tiny and difficult to see, even with 10X magnification. These mites are visible under magnification when galls are forming.
The mites are light colored and carrot shaped.

Damage/Symptoms: Male ash flowers are on different trees than female ash flowers. Male trees are used widely in ornamental plantings. Heavy infestations do not affect tree health negatively but may be considered unsightly. The galls are formed on the flowers, causing severe distortion and fusing of the flowers. The gall starts out green in color and matures to brown. Galls are persistent, remaining attached to the twigs for several seasons.

Comments: Sprays will not improve tree health but may be used when blossoms start to form for improved aesthetic value.

■ Pest: **Ash/lilac borer**
(*Podosesia syringae*) family Sesiidae

Host(s): Ash, lilac

Description/Biology: The ash/lilac borer adult is a clear-wing moth that resembles a paper wasp. The wings are narrow, dark brown and transparent and the bodies are dark

brown/black with a yellow band on the abdomen. Adults emerge in May to June and lay their eggs in bark crevices. Larvae require three years to mature. During the first summer, larvae feed within the bark. Larvae then feed into the wood during the second year, and bore toward the surface just under a thin layer of bark during the third year. Fully grown larvae are 1 inch long with creamy white bodies and brown heads. Pupae push their way to the surface just prior to adult emergence.

Damage/Symptoms: Feeding beneath the bark damages the plant's food and water-conducting tissue. Sawdust can be seen around tunnel entrances and at the bases of trees. Tunnel entrances are about ¼ inch in diameter. The area around entrance holes may die, producing targetlike sunken areas. Boring causes dieback of limbs and may kill young trees. Infestation often occurs at injury sites, such as those that lawn mowers, weed trimmers or previous ***Podosesia*** attacks cause.

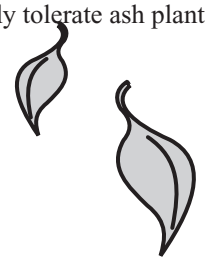
Comments: An Ichneumonid wasp, ***Phaeogenes ater,*** is a parasite of ash/lilac borer, but little is known about its effectiveness as a biocontrol agent. These borers often infest trees that are under considerable stress, but apparently healthy trees also are infested. See "Maintaining Healthy Trees and Shrubs." To use insecticides, spray the trunk and lower branches with permethrin three times at three-week intervals beginning 10 to 14 days after the first adults emerge (mid-May to early June) and ending when adult flight stops (mid to late July). Pheromone traps are available commercially for monitoring and improving spray timing.

■ Pest: **Ash plant bug**
(*Tropidosteptes amoenus* and other *Tropidosteptes* spp.) family Miridae

Host(s): Green ash

Description/Biology: This insect produces two generations per season. They overwinter as eggs imbedded in bark. Green to tan nymphs emerge in the spring and feed on the undersides of the leaves. First-generation adults emerge in midsummer. Adults are tan colored with pinkish markings on the back and are about ½ inch long. Second-generation adults appear during late summer and remain active until a severe frost occurs.

Damage/Symptoms: Plant bugs pierce host tissues and suck plant sap, causing yellow spotting of leaves. Severe infestations cause leaf mottling, deformed leaves and sometimes premature leaf drop. Trees usually tolerate ash plant bug damage well and the damage normally is not severe enough to cause defoliation or warrant control.



Comments: As numbers increase through the summer, damage to foliage occasionally can be significant. Control is justified when leaf injury is found easily throughout the canopy. Carbaryl and permethrin may be used to manage ash plant bug.

■ Pest: **Blister beetles**
(*Epicauta* spp. or *Lytta* sp.) family Meloidea

Host(s): Caragana, green ash, honeysuckle

Description/Biology: Several species of blister beetles can feed on the foliage of shrubs and trees. Blister beetles have a similar body shape: long, narrow, first body segment narrower than the head or remainder of the body ("necklike"). The most common blister beetles causing problems in ornamentals are the Ashgray ***(Epicauta fabricii)*** and Nuttall ***(Lytta nuttalli)*** — metallic green, red or purple. These beetles have body fluid containing cantharadin, a blistering agent. They produce one generation per year. Adults emerge in late spring and early summer. They lay eggs in moist soil. The larvae live in the soil, where they are predators on grasshopper egg pods and bee larvae. The larvae survive the winter and complete development in the spring.

Damage/Symptoms: The adults feed on plant foliage. The beetles are very mobile and tend to congregate in swarms to feed. Defoliation is localized due to the swarming behavior. When populations are large, young caragana shelterbelts may be damaged.

Comments: Blister beetle populations normally increase following outbreaks of grasshoppers within the region. Beetles may be sprayed with carbaryl or methoxychlor as large populations become evident, but before serious damage has occurred.

■ Pest: **Boxelder erineum gall mite**
(*Cosetacus negundi*) family Eriophyidae

Host(s): Boxelder ***(Acer negundo)***

Description/Biology: These mites are white, slender and spindle-shaped. Mites remain in galls until the leaves mature.

Damage/Symptoms: Large, rounded, pouchlike galls develop on the underside of the leaves as thick cavities with a dense mass of white hairs. Hairs protrude on the upper side of the leaf. The galls are solitary, do not occur on veins and can be widespread on the leaves. These galls do not damage the health of infested plants substantially.

Comments: Earliest foliage often is affected, especially leaves nearest the trunk or on larger limbs. See "Mites (gall,

rust, bud and blister)." Treatments are not necessary.

■ Pest: **Boxelder twig borer**
(*Proteoteras willingana*) family Tortricidae

Host(s): Boxelder

Description/Biology: The moths emerge in late June or early July. The moths are gray with dark brown markings and have a wingspan of ½ to ¾ inch. They lay eggs singly on the undersides of leaves. The larvae hatch in early July. Larvae feed on leaves first, then bore into shoots or buds by early August. These larvae hibernate for the winter, resuming feeding in the spring. They attack new buds in the spring. Larvae are creamish to gray colored with dark spots at the base of hairs. The larval head capsule is black. Mature larvae are less than ½ inch long.

Damage/Symptoms: Newly hatched larvae skeletonize the undersides of leaves. By August, larvae bore into shoots. Frass and silk plug entry holes. In the spring when larvae resume tunneling, the entrance hole and frass plug are visible, along with swelling of the infested shoot. In ornamental plantings, the boring habits of the larvae result in a bushy growth that is unattractive.

Comments: If problems develop, insecticide treatments directed at leaf-feeding caterpillars in July should provide effective protection.

■ Pest: **Bronze birch borer**
(*Agrilus anxius*) family Buprestidae

Host(s): Birch

Description/Biology: The adult belongs to a group called metallic wood-boring beetles. The beetles are bullet-shaped, less than ½ inch long and olive green with metallic bronze reflections. The larvae are known as flat-headed borers. The legless larvae have a flat, brown head, are creamy white and have a distinctly segmented body. They reach a length of 1¼ inches when fully grown. The life cycle may last from one to two years. Adults emerge from infested trees from late June until August. They lay eggs in bark crevices of weak or dying trees. They infest limbs 1 inch in diameter or less first, larger limbs and trunks later. Larvae hatch and tunnel beneath the bark. The larvae pupate in a chamber in the sapwood.

Damage/Symptoms: Young, transplanted birch trees and weakened or dying trees are at greatest risk for infestation. Infestations start on smaller branches, killing upper branches first. Larval feeding produces meandering tunnels beneath the bark. Infested branches may appear bumpy. The exit hole for the adult is D-shaped. Bronze birch borer is the limiting problem for birch in North Dakota.

Comments: Insecticidal control is best directed at adults to prevent egg laying. Spray the bark surface of the trunk and limbs with permethrin in mid-June and twice more at three-week intervals until August. Insecticide injections, by trained professionals, have shown variable results. Heavily infested limbs and trees should be destroyed. The brown-barked river birch is resistant to bronze birch borers.

■ Pest: **Cankerworm, fall**
(*Alsophila pometaria*) family Geometridae

Host(s): Variety of hardwoods, especially linden, bur oak, elm, green ash, maple, white birch

Description/Biology: The insects produce one generation per year and it overwinters in the egg stage. Eggs hatch into larvae that feed on the foliage beginning in the spring. Larvae are slender and about ¾ to 1¼ inches long when mature. Color varies from light green with white lines to brownish green with dark bands down the back. Larvae have three pairs of prolegs, with one pair being rudimentary. Larvae crawl using a looping behavior. In midsummer, larvae pupate in cocoons in the soil. Adults emerge in the fall. Wingless females must crawl from the ground up the tree to lay masses of 100 eggs high up on the trunk and branches of trees. Females are about ¾ inch long, brownish gray and do not have spines. Males also are brownish gray with irregular light bands on the forewings.

Damage/Symptoms: Young larvae feeding causes a shot-hole appearance in the leaves. Older larvae consume leaves, defoliating entire trees or groups of trees when populations are high. Repeated defoliation for three or more consecutive years will stress trees, decrease the tree's aesthetic value and may kill tree branches.

Comments: Placing a 3- to 4-inch band of sticky material, such as Tanglefoot®, in early September is a common technique used to prevent the wingless female moth from crawling up the tree to lay her eggs. Apply the sticky material to a waterproof material wrapped around the tree. This prevents absorption and allows for removal of the sticky substance at the end of the pest season. Insecticidal treatments should be directed at the caterpillars in late spring or early summer. Acephate, Bt, carbaryl and permethrin are registered for fall cankerworms.

■ Pest: **Cankerworm, spring**
(*Paleacrita vernata*) family Geometridae

Host(s): Variety of hardwoods, especially linden, bur oak, elm, green ash, maple, white birch

Description/Biology: The insects produce one generation per year and it overwinters as larvae in earthen chambers. Larvae pupate and the spiny, wingless female emerges in early spring. Females lay masses of about 100 eggs in crevices of bark on the lower trunks of hosts. The difference between the spring and fall cankerworm is when the eggs are laid — spring cankerworm in early spring and fall cankerworm in September. Young larvae hatch from the eggs and feed on the buds and unfolded leaves. Larval feeding and development are similar to the fall cankerworm. Larvae range in color from yellow-green to almost black and have a yellow stripe along the side of the body. Another differentiating characteristic of spring cankerworm larvae is the two pairs of abdominal prolegs (fall cankerworm have three pairs) and a pair of tubercules on the dorsal surface of the abdomen. Larvae are slender and about ¾ to 1½ inches long when mature. Larvae crawl via a looping behavior and the wind often blows them as they hang from their own strands of silk.

Damage/Symptoms: As with the fall cankerworm, larval feeding causes defoliation. Repeated defoliation for three or more consecutive years will stress trees, decrease aesthetic value and may kill tree branches.

Comments: Banding of tree trunks with a sticky material such as Tanglefoot® is a common technique used for cultural control. A 3- to 4-inch band of sticky material applied in mid-March is used to prevent the wingless female moth from crawling up the tree. Apply the sticky material to a waterproof material wrapped around the tree. This prevents absorption and allows for removal of the sticky substance at the end of the pest season. Insecticidal treatments should be directed at the caterpillars in late spring or early summer. Bt, carbaryl and permethrin are registered for spring cankerworms.

■ Pest: **Carpenterworm**
(*Prionoxystus robiniae*) family Cossidae

Host(s): Variety of hardwoods.

Description/Biology: The moths are mottled gray with wingspans of 2 inches (males) to 3 inches (females). The wood-boring caterpillars are greenish white with brown heads or spotted and pinkish with reddish brown heads. Fully grown larvae are 2 to 3 inches long. The life cycle of carpenterworms requires three years. Adults emerge in June. Females deposit eggs in bark crevices or wounds on the trunk or branches. The larvae tunnel through the cambium layer and into the wood, keeping the gallery clean of frass. Larvae pupate in May of their last year of development.

Damage/Symptoms: Carpenterworms are common pests of poplar and ash in windbreaks. The extensive tunnels often break through the surface of the bark. Although carpenterworms seldom kill trees, their feeding makes trees susceptible to breaking in strong winds. Wounds on the bark are very attractive egg-laying sites. The exit holes are round and may be up to 5/8 inch in diameter.

Comments: Carpenterworms often are found in trees of low vigor, but apparently healthy trees may be affected if the trees have a bark opening. See "Maintaining Healthy Trees and Shrubs."

■ Pest: **Chokecherry midge**
(*Contarinia virginianiae*) family Cecidomyiidae

Host(s): Chokecherry (Prunus virginiana)

Description/Biology: Gall midges are tiny, slender, fragile flies smaller than mosquitoes. Little information has been published on the chokecherry midge. The adults likely are active during bloom or early fruit set. Their small orange maggots develop in the fruit. Larvae remain in infested fruit, which dries up and drops to the ground before harvest. Some fruit may remain attached to the plant. Other midge in the region overwinter as larvae in the soil, complete development in the spring and emerge as adults.

Damage/Symptoms: Infested fruits are enlarged and pear-shaped. The larvae destroy the seed and leave the fruit hollow.

Comments: Removing and destroying the infested fruit soon after it appears reduces the number of surviving midges for the next season. No chemical treatments have been proven effective for this pest.

■ Pest: **Chokecherry pocket gall mite**
(*Eriophyes emarginatae*) family Eriophyidae

Host(s): Chokecherry ***(Prunus virginiana)*** and other ***Prunus*** spp.

Description/Biology: These mites are small, whitish and wormlike. They produce one generation per year. Fertilized females overwinter in crevices of old buds near the base of branches. The females move to newly developing leaves in the spring.

Damage/Symptoms: Pouchlike galls are formed at random over the surface of the leaves. Galls are elongate, or finger-like, and erect. Galls become more visible when they turn yellowish to light brown. The galls cause little damage to trees but create an undesirable appearance in ornamental plantings.

Comments: See "Mites (gall, rust, bud and blister)."

■ Pest: **Cottonwood leaf beetle**
(*Chrysomela scripta*) family Chrysomelidae

Host(s): Poplars, willows

Description/Biology: Adult beetles are ¼ to 1/3 inch long. The head is black and the pronotom is dark with reddish margins bearing a dark spot. The hard wing covers (elytra) are yellowish with a dark line on the inner edge and seven elongate dark spots. The eggs are yellow and laid in clusters on the leaves. The larvae have black heads, well-developed legs and yellowish bodies with two rows of black spots along the back. The adult beetles overwinter in leaf litter, emerging when leaves first appear. Both adults and larvae feed on foliage. The larvae feed for about two weeks, skeletonizing the undersides of the leaves. Pupae hang from the leaves. From egg to adult requires about six weeks. Two generations occur annually.

Damage/Symptoms: Larvae skeletonize leaves. They prefer young foliage. Large larval populations can kill leaders, resulting in deformed growth. Large numbers of adults can be found in the fall at the base of infested trees.

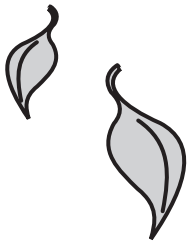
Comments: Can spray ***Bacillus thuringiensis*** (Bt) "San Diego" or pyrethrins on young larvae. Should use a synthetic insecticide, such as carbaryl, on adults and older larvae.

■ Pest: **Cottony maple scale**
(*Pulvinaria innumerabilis*) family Coccidae

Host(s): Boxelder, elm, honeylocust, linden, maple, poplar, other hardwoods

Description/Biology: The brown, flat, inconspicuous, immature female scales overwinter on twigs. In the spring, the females complete development and produce their large, white cottony egg sac. The tiny, transparent crawlers hatch in late June to early July, moving to the undersides of leaves to feed. Males mate with immature females in late summer. Before leaves drop in the fall, the females move back to the twigs and attach themselves for overwintering. The insects produce one generation per year.

Damage/Symptoms: Scale insects have piercing-sucking mouthparts that they insert into leaf veins to draw out plant sap. Feeding can cause twig dieback. Severe infestation may kill major limbs. Honeydew, which the scales produce, coats the leaves and promotes the growth of black sooty mold fungi. In late spring, heavily infested branches with white egg sacs look as though they have been strung with popcorn.



Comments: Dormant oils are directed at the overwintering scales on the twigs. Insecticides are used against the young crawlers and treatments are timed with hatching in late June.

■ Pest: **Eastern spruce gall adelgid**
(*Adelges abietis*) family Adelgidae

Host(s): Spruce

Description/Biology: Adelgids are small aphidlike insects. They produce two generations per year of ***A. abietis*** and both generations consist entirely of females that reproduce asexually. The adelgids overwinter as partly grown nymphs attached to the base of spruce buds. Females mature in April or May and lay between 100 and 200 eggs at the bases of needles. Eggs hatch in about a week, and the new nymphs feed at the bases of needles, causing twigs to swell. As the twig swells, a gall is formed, and the nymphs complete their development in the cavities of the gall. Later in the summer, winged females emerge from the galls and lay their eggs on the needles of nearby branches. These eggs hatch and the nymphs overwinter.

Damage/Symptoms: Adelgids suck plant juices. ***A. abietis*** causes pineapple-shaped galls or swollen twigs that affect shoot growth. Galls become unsightly in heavily infested trees but are unlikely to harm trees seriously.

Comments: Can apply a summer spray of soap, oil or conventional insecticide, such as carbaryl, around bud break. Remove galls and destroy.

■ Pest: **Eastern tent caterpillar**
(*Malacosoma americanum*) family Lasiocampidae

Host(s): Chokecherry, pin cherry, occasionally other hardwood species

Description/Biology: This insect produces one generation annually and it overwinters as fully developed embryos within the eggs. Larvae are gregarious and construct tent-like nests of silk in the forks of trees. They use the tents as shelter or resting places. The larvae forage during the day for new foliage in nearby branches. Larvae feed for six to eight weeks and are about 2 inches long when mature. Larvae are black and somewhat hairy with a whitish yellow stripe down the middle of the back, narrow broken orange-colored subdorsal stripes, and lateral white and blue markings. When mature, they disperse and spin cocoons in sheltered places. Adult moths appear during early summer (late June or early July) and lay their eggs in a bandlike cluster

of 150 to 350 eggs around a small twig, covering them with a froth substance called spumaline. Adult moths are yellowish brown, medium-sized (1- to 1 ½-inch wingspans) and stout bodied, with hairy bodies, legs and eyes. Two oblique whitish bands run across the forewings.

Damage/Symptoms: Larval feeding disfigures ornamental plants, but plants usually are not damaged permanently. Webs are unsightly.

Comments: When populations are high, usually at 10-year intervals, whole trees can become covered with webbing and defoliated. Egg masses should be destroyed when they are seen. Bt works well to control young larvae, while pyrethrins or synthetic insecticides are needed for older larvae.

■ Pest: **Elm leaf beetle**
(*Pyrrhalta luteola*) family Chrysomelidae

Host(s): European species of elm are most susceptible to damage. Siberian and American elms are somewhat resistant.

Description/Biology: Adults are olive green with black longitudinal stripes along the margin and center of the back. They overwinter as adults in protected places such as sheds, bark crevices or house shingles. Beetles occasionally become a nuisance inside homes when seeking overwintering sites. Adults emerge from overwintering sites in the spring and feed on elm leaves, chewing small, circular holes. Female beetles lay double-row clusters of five to 25 eggs on the underside of leaves, with a total of 600 to 800 eggs in their life span. Tiny black, grublike larvae hatch from the eggs and begin to feed on the leaves. As larvae mature, their color changes to green, then to yellow with dark tubercles that form two black lateral stripes. Larvae crawl down tree trunks to pupate on the ground at the base of trees, or in cracks or crevices on the trunk. A new generation of adults emerges from the pupae in about two weeks. New adults fly back to the foliage for feeding and egg laying. In late summer or fall, the adult beetles leave the host tree and seek an overwintering site. They usually produce two generations per year.

Damage/Symptoms: Larval feeding skeletonizes foliage, while adult feeding causes a shot-hole pattern. Damage is most severe when beetles attack a tree for several consecutive years, causing premature leaf drop, limb dieback or even tree death.

Comments: Apply boiling water, light oil or insecticides to kill larvae congregating at the base of elms. Spray adults and larvae with carbaryl, permethrin, spinosad or cyfluthrin when the weather is NOT hot and dry. Trunk injections have shown favorable results.

■ Pest: **Elm sawfly**
(*Cimbex americana*) family Cimbicidae

Host(s): Aspen, linden, elm, willow, other hardwoods.

Description/Biology: Mature larvae are 2 inches long and have wartlike bumps on their bodies. Elm sawflies overwinter as pupae in cocoons spun on the ground beneath plant litter. The adults emerge in mid-June. The adults are heavy-bodied sawflies that are 1 inch long. Their wings are smoky colored. They have knobbed antennae and black heads. The abdomen of the female is black with yellow spots.
The male's abdomen is reddish brown to purplish black. The larvae are gray when they first hatch but change to yellowish green with a blue and black line the length of their back as they grow older. The females lay eggs in pockets that they cut into the undersides of leaves. Eggs hatch in about seven to 10 days. Larvae feed until late August, when they drop from the tree and spin their cocoons. They produce only one generation per year.

Damage/Symptoms: Elms and willows are the most commonly infested trees. The larvae defoliate trees.
Larvae reach mature size and consume most of the foliage in late summer. The larvae often are found in large groups, particularly when they drop from trees and prepare to spin cocoons for the winter.

Comments: Elm sawfly outbreaks are rare. Treatment with conventional insecticides has proven effective, particularly if larvae are treated when damage is first observed.

■ Pest: **European elm bark beetle**
(*Scolytus multistriatus*) family Scolytidae

Host(s): Elm

Description/Biology: The adult is shiny dark brown to black and about 1/8 inch long. Female beetles lay eggs in elm limbs, trunks or recently cut elms. Adults feed in crotches of living elm twigs, causing twigs to die and drop. If the adult is contaminated with the spores of the Dutch elm disease fungus, it can transmit the disease to healthy elms during feeding. After feeding, the female moves to recently cut elm logs or limbs or trunks of stressed trees and bores a 1- to 2-inch breeding gallery, where it lays about 36 eggs. Egg-laying galleries usually are parallel to the wood grain. Larvae hatch from the eggs and bore larval galleries perpendicular to the egg-laying galleries. The insects usually produce two generations per year. The second generation of beetles overwinters as larvae, pupae or adults beneath bark.

Damage/Symptoms: European elm bark beetles are a major vector of Dutch elm disease, causing devastating tree mortality.

Comments: This is an exotic pest that does not overwinter well in North Dakota and does so most often in protected sites. This is why elimination of elm firewood piles is so important in Dutch elm disease control.

■ Pest: **European elm scale**

(Gossyparia spuria) family Eriococcidae

Host(s): Elm

Description/Biology: Male and female elm scale differ in appearance. Immature males attached to bark in late winter make a white, feltlike cocoon that resembles a rice grain and may have long filaments protruding from the posterior end. Females produce tough, feltlike white rings surrounding their oval, grey to brown body, giving them a mealybuglike appearance. When crushed, these scales exude red fluid. They produce one generation each year. They overwinter as second-instar nymphs in cracks in the bark, clinging tightly to buds or at the base of twigs. Eggs, produced in late June to mid-July, hatch within the body of the females and the bright yellow crawlers move to the undersides of leaves to feed. The crawlers are found along the leaves midvein or other prominent veins. As the crawlers mature, they begin to resemble mealybugs.
The crawlers will move back to twigs and branches in the fall to overwinter.

Damage/Symptoms: European elm scale feed on phloem juices. They suck out more than they can use and excrete it as honeydew that drips from leaves and twigs. Cars parked under elms in the summer may be casualties of these honeydew drippings. Leaves may become prematurely yellow and wilt. Twigs may die back by midsummer in extreme infestations. Lower leaves are especially susceptible to yellowing, and sooty molds may develop on the honeydew-covered leaves. Severely injured leaves do not drop but remain on the tree during the winter.

Comment: This insect pest has been observed on trees in western North Dakota, and is known to have killed two small elms in Dickinson. Dormant oils may be used on the overwintering nymphs. Properly timed horticultural oils and insecticides (acephate, carbaryl and malathion) may be used to control the crawlers. Soil treatments with the systemic insecticide imidacloprid have been successful in Colorado.

■ Pest: **European fruit lecanium scale**

(*Parthenolecanium corni*) family Coccidae

Host(s): Ash, elm, boxelder, fruit trees, poplar, willow, other hardwoods

Description/Biology: They are ¼ inch in diameter, hemispherical in shape, and the reddish brown protective cover of the female is the stage seen most often. They lay eggs in June beneath the protective cover. The white crawlers, or nymphs, hatch from late June to mid-July. Crawlers migrate to leaves, feeding on the undersides of leaves near the midvein. By late August, the crawlers move back to the bark to hibernate in bark crevices. In the spring, crawlers move to twigs, where they complete development. They produce only one generation per year.

Damage/Symptoms: Large clusters of the reddish brown mature scales can be seen on branches and twigs. They produce sticky honeydew, making foliage appear wet. Large populations may weaken or kill twigs and branches.

Comments: Insecticide treatments, such as acephate, are most effective when applied to the crawlers as they hatch in early July.

■ Pest: **Fall webworm**

(*Hyphantria cunea*) family Arctiidae

Host(s): Alder, aspen, birch, chokecherry, cottonwood, elm, fruit trees, maple, pin cherry, poplar, willow, other hardwoods.

Description/Biology: These insects produce one generation per year and it overwinters in the pupal stage. Adults emerge late June to mid-July and are mostly white. Females lay large egg masses on the undersides of leaves. Eggs hatch into larvae after about 10 days. Larvae feed until late summer or early fall in silken nests at the ends of tree branches. As the colony grows, it adds more leaves to accommodate the food needs. Mature larvae (about 1 inch long) are whitish with a broad dark band, and have long white or black hairs arising from reddish orange projections along the body.

Damage/Symptoms: Silken nests are very unsightly in nurseries, city parks and yards. Fall webworms cause more of a nuisance than a threat to the health of the tree.

Comments: Nests may be pruned out and disposed of as soon as they appear. Caterpillars feed within the web, making control with insecticidal sprays difficult. Early sprays with Bt, acephate, carbaryl, malathion or permethrin before nests appear usually are effective. When webs have formed, the nest should be opened before any insecticides are applied.

■ Pest: **Fletcher scale**
(*Parthenolecanium fletcheri*) family Coccidae

Host(s): Arborvitae, juniper, yew

Description/Biology: The female scales overwinter as reddish brown nymphs, completing development in the spring and laying eggs. The mature female is yellowish brown, hemispherical in shape and about 1/6 inch in diameter. The oval, flat, yellow crawlers hatch in late June. The insects produce one generation per year.

Damage/Symptoms: The crawlers do not migrate very far from their hatching site. This results in concentrated infestations on certain branches. The scales produce honeydew, coating the plant. Black sooty mold grows on the honeydew, contributing to plant stress.

Comments: The eggs hatch during a short period of time. Summer sprays of soap or oil directed at the crawlers in early July can be very effective in reducing the population.

■ Pest: **Forest tent caterpillar**
(*Malacosoma disstria*) family Lasiocampidae

Host(s): Ash, aspen, linden, birch, cottonwood, elm, maple, oak, poplar, other hardwoods

Description/Biology: Similar to the eastern tent caterpillar. It produces one generation annually, which overwinters as fully developed embryos in eggs. Larvae hatch in early spring, usually coinciding with flushing of aspen foliage. The fully mature larvae (2 inches long) are easily identified from other caterpillars by the keyhole-shaped spots along their backs and broad bluish lateral bands. Larvae gather on their silken mat spun on branches and start their foraging. In five to six weeks, the larvae pass through five larval instars and form silken cocoons to pupate. The stout-bodied moth emerges from the cocoon after about 10 days. The adult moth is light yellow to buff brown in color with two oblique dark bands on the forewings and a wingspan of about 1 to 1½ inches. A female deposits 150 to 200 eggs around small twigs and covers them in a frothy substance called spumaline. The embryos develop into larvae in about a month.

Damage/Symptoms: Larvae cause defoliation. Light defoliation has little effect on tree growth. Two or more years of moderate to severe defoliation is necessary to affect radial growth and cause branch and twig mortality. People also find the wandering masses of larvae to be extremely objectionable. Unlike other tent caterpillars, the forest tent caterpillar does not develop webs.

Comments: Outbreaks typically last for two to four years in North Dakota. Bt works well to control young caterpillars, while permethrin, pyrethrins or other insecticides are needed for older larvae.

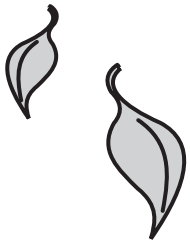
■ Pest: **Honeylocust pod gall midge**
(*Dasineura gleditchiae*) family Cecidomyiidae

Host(s): Honeylocust

Description/Biology: The small midges, 1/10 inch long, are black (males) or black with red abdomens (females). They become active when new growth appears in the spring. They lay eggs on young leaflets. The cream-colored larvae feed on the leaf, stimulating the growth of a pod. The larvae feed within the pod. They produce three to five generations per year.

Damage/Symptoms: Infested leaflets develop into a pod-like gall. One or more larvae may be within a gall. The galls dry up and fall from the tree after the adult midge emerges. With heavy infestations, twig dieback can occur. New shoots form at the base of dead twigs. Trees are not killed, but the infestation reduces trees' ornamental value.

Comments: Insecticide treatments with spinosad or carbaryl, timed to coincide with spring growth, and follow-up applications at two-week intervals, can reduce infestations.



■ Pest: **Honeysuckle aphid**
(*Hyadaphis tataricae*) family Aphididae

Host(s): Honeysuckle

Description/Biology: The aphids are pale green to cream colored with a fine powdery wax on their 1/16-inch-long bodies. Females lay eggs on shoots and twigs in the fall. The eggs overwinter and hatch at the time buds break in the spring. These aphids are all females and bear live young. They feed on the undersides of leaves and new shoots. Later, the aphids feed on the top side of leaves.

Damage/Symptoms: Infested leaves cup upward. The aphid's saliva contains a toxin that stunts the growth of new shoots, creating an unsightly witches'-broom effect. Witches'-brooms may die over winter, and severe infestations can kill branches or whole plants.

Comments: Check with local nurseries for tolerant honeysuckle cultivars. Tolerant cultivars include Clavey's Dwarf, Dropmore Scarlet Trumpet, Emerald Mound and Miniglobe. For susceptible cultivars, treatments with acephate or permethrin when aphids first appear in the spring may be helpful. Avoid actions that stimulate succulent growth (e.g., pruning, fertilizing), as such tissue is more prone to infestation.

■ Pest: **Introduced pine sawfly**
(*Diprion similis*) family Diprionidae

Host(s): Austrian, jack, red, scotch and white pines

Description/Biology: Female adults are black and yellow with threadlike antennae and average 1/3 inch long. The male sawflies are brown and black with broad, feathery antennae and are slightly smaller. They produce two generations per year. They overwinter as pre-pupae in leaf litter. Adults appear May to June, and females insert about 10 eggs in a row into a single pine needle. Females deposit an average of 70 eggs during their lives. Larvae hatch in 10 to 14 days. They feed on the outer portion of the needles early on and entire needles later. Sawfly larvae have more than five pairs of abdominal prolegs, while caterpillars have less than six pairs of prolegs. The larva changes color as it matures, from dull gray to black with white and yellow spots, a shiny black head and a dark, double stripe down the back. In late July, larvae spin cocoons among needles in bark crevices and at the bases of small branches. The second generation appears in early August. Eggs hatch in seven to eight days. Larvae feed until September and eventually spin cocoons for overwintering.

Damage/Symptoms: Larval feeding causes defoliation. Damage appears as missing needles or needle parts, with ragged, shredded edges on partly consumed needles. When defoliation is heavy late in the season, branches or entire trees may be killed.

Comments: Bt is NOT effective against sawflies. Insecticidal soap, carbaryl, methoxychlor or permethrin may be used. Spray larvae when more than 10 larvae are found on one- to four-year-old trees. Treat trees before damage is severe.

■ Pest: **Maple bladdergall mite**
(*Vasates quadripedes*) family Eriophyidae

Host(s): Red and silver maples

Description/Biology: This is a small, white, spindle-shaped mite. The mites overwinter as females that move onto the foliage in the spring. They have an in-season generation of males and females.

Damage/Symptoms: The pouch-type gall, known as a bladder gall, is visible on the upper leaf surface. The galls are variable in shape, ranging from rounded to elongate. The outside of the galls appear wrinkled. They change in color from yellowish green to pink to brown to black. The inside is hollow with an opening on the underside of the leaf. With heavy infestations, leaves become wrinkled and may drop prematurely. The galls cause little damage to the tree but appear unsightly on ornamental plantings.

Comments: See "Mites (gall, rust, bud and blister)."

■ Pest: **Mites**
(Gall, Rust, Bud, and Blister)

Mites that cause plants to produce galls are extremely small and invisible to the naked eye. The Eriophyidae (er e ó fi de) mites stimulate plants to produce bladder galls, spindle galls or dense masses of hairy growths (erinea). The growths cause concern for tree owners, but their presence rarely is detrimental to the health of the tree. Sufficient foliage usually remains unaffected during the season to maintain a healthy plant.

These mites are soft-bodied and spindle-shaped. They are unique among mites in having only two pairs of legs.

The life cycles of these mites are similar and rather simple. Some eriophyid mites on deciduous trees have a more complex life cycle that has only females in the overwintering generation and both sexes during the growing season. These mites are very specialized, feeding on a very narrow range of host plants; in many cases, only a single species.

Gall formation results from a mite feeding on an individual plant cell. Symptoms of injuries may appear on buds,

shoots, twigs, stems, flowers and fruits. Symptoms are described as blisters, rosettes, scales, enlarged buds, witches'-brooms and erinea (hairy growths). Symptoms generally are specific to host and mite and are useful for diagnosing the problem.

■ Pest: **Native elm bark beetle**
(*Hylurgopinus rufipes*) family Scolytidae

Host(s): American and Siberian elms

Description/Biology: Adult beetles are about 1/8 inch long and dull brown to black. Their abdomens are rounded, unlike the concave rear with a spine of the European elm bark beetle. The larva is a white, legless grub with a pale brown head. They produce only one generation per year. They pass the winter as either larvae or adults. Adults that overwinter are in tunnels made in the thick bark at the base of elm trees. They emerge in May, burrow into bark and excavate their egg galleries. The egg gallery generally extends across the grain of the wood, not parallel like the European bark beetle. Larvae feed beneath bark, tunneling away from the egg gallery, creating a fanlike pattern.

Damage/Symptoms: The elm bark beetles transmit the fungus Ophiostoma ulmi, which causes Dutch elm disease (DED). The native elm bark beetle prefers branches 2 to 4 inches in diameter. This results in infections starting 10 to 20 feet inside the edge of the tree canopy. The resulting DED symptoms are wilting and browning of an entire branch or area of the crown. Infected sapwood develops brown streaks.

Comments: Insecticide treatments with permethrin applied in late summer and fall to the lower 9 feet of the trunk can reduce successful boring of the overwintering native elm bark beetle adults. An early spring treatment may offer additional protection. This approach is beneficial near river corridors, where beetle populations are high. DED affects the American elm most seriously. Siberian elm is more tolerant.

■ Pest: **Oak bullet gall wasp**
(*Disholcaspis quercusmamma*) family Cynipidae

Host(s): Bur oak

Description/Biology: This tiny cynipid wasp causes persistent galls. The wasps are less than ¼ inch long, black to brown in color and antlike in appearance. The life cycle is not well-understood. The larvae are white, legless and without a distinct head. The larvae are found in the galls. Females emerge in the fall and lay eggs near bud scales. Eggs hatch in the spring and larval feeding stimulates gall formation. More than one generation is likely per season.

Damage/Symptoms: The 1/3-inch diameter gall is woody, tan and round with a rough surface. They are found on the twigs in clusters of three or more. Twig galls may cause injury to trees, but their presence rarely damages healthy trees.

Comments: Oak trees have a number of gall-forming insects associated with them and they generally are not harmful to the health of the trees. The different gall wasps produce their own distinctive galls.

■ Pest: **Oak lace bug**
(*Corythucha arcuata*) family Tingidae

Host(s): Bur oak

Description/Biology: Overwintering adults lay eggs in the spring. They have five nymphal stages. The nymphs are blackish with white markings and have spines on the abdomen. They mature to the adult form by midsummer. They produce two generations per year, with the second generation completing development by fall. The adults are an inch long. The wings of these true bugs have a lacelike appearance. The insects' wings are partially transparent except for dark markings at the base of the wings.

Damage/Symptoms: The nymphs feed in groups on the undersides of leaves. They deposit specks of tarry excrement. Leaves become mottled with loss of chlorophyll at feeding sites. Injured leaves are leathery, often dropping prematurely when trees are water stressed.

Comments: Damage rarely is harmful to the tree. The greatest concern is with ornamental plantings where foliage becomes discolored. Summer sprays of soap or oil controls nymphs, and acephate, malathion or permethrin kill adults and nymphs. None of these treatments kill eggs.

■ Pest: **Oystershell scale**
(*Lepidosaphes ulmi*) family Diaspididae

Host(s): Wide variety of hardwoods

Description/Biology: Mature females lay eggs in the fall and the eggs overwinter beneath the protective coverings. The pearly white, oval eggs hatch in mid to late June. The crawlers move around until they locate a favorable feeding site on twigs and branches. Then they insert their mouthparts and begin feeding. As they grow, they lose their legs and increase the size of the protective covering. The covering of a mature scale is brown to gray and resembles a tiny oyster shell, 1/8 inch long. The female scale dies after laying eggs.

Damage/Symptoms: The oystershell scale can be found on many different hosts. It can be very damaging to lilac, ash and dogwood. When present, the scales can be so abundant that the protective shells form a crust on branches of the host plant. Heavily infested branches lose vigor and dieback can occur.

Comments: Treatments with summer sprays of oil or soap should be applied by the first week of July or when crawlers are observed emerging from under the shells. Acephate, carbaryl or malathion will kill crawlers; however, these chemicals also will kill natural enemies of the scale insects and ultimately could make the infestation worse. Since shells do not fall off after death, good assessment of treatment performance requires removal of shells. A shell is easily dislodged with a thumbnail.

■ Pest: **Pear slug sawfly**
(*Caliroa cerasi*) family Tenthredinidae

Host(s): Cotoneaster, fruit trees, hawthorn, mountain-ash

Description/Biology: These insects overwinter in the ground as fully grown larvae. Larvae look like slugs and are dark olive green to black and covered with slime, changing to translucent yellowish green as they age. In spring, larvae pupate and emerge as adults in June. Adults are shiny black with dark wings and are about 3/16 inch long. Adults deposit eggs singly on the lower leaf surface. Larvae hatch from the eggs in about two weeks and feed on the upper leaf surface for about four weeks. Mature larvae drop to the ground to pupate. A second generation emerges by August. They may produce one or two generations per year, depending on the weather.

Damage/Symptoms: Defoliation occurs because of leaf skeletonization and premature leaf drop. It usually has little detrimental effect on the hosts, but the skeletonized leaves and the sluglike larvae are unsightly.

Comments: The exposed larvae are easy to control during feeding. A strong jet of water can wash them from the foliage. Sprinkling wood ash on larvae will provide excellent control. Summer oils, insecticidal soap and conventional insecticides labeled for sawflies also work well.

■ Pest: **Pine moth**
(*Dioryctria* sp.) family Pyralidae

Host(s): Pines, spruce

Description/Biology: Little is known about pine moth life history in North Dakota. These moths overwinter in the larval stage in silken cases. Adults become active and emerge in May. Adults have narrow forewings and range from gray to reddish brown in color. The hind wings are unmarked with a narrow dark border. A wing span of 1 to 1¼ inches is typical for this genus. Larvae bore into bark, stems, shoots or rust galls during the summer. Larvae usually are pinkish green and up to ¾ inch long. Pupation occurs during midsummer and adults emerge about three weeks later, usually mid-July to August. The larvae from these adults overwinter.

Damage/Symptoms: Pitch masses are characteristic at the entrance to the tunnel. They often occur on the stem at a branch whorl or on shoots near the terminal leader. Symptoms also may appear as a discolored or broken leader (sometimes a lateral) directly above the pitch mass. This damage may be confused with wind or snow damage. Repeated stem attacks may cause branches to break at the points of injury.

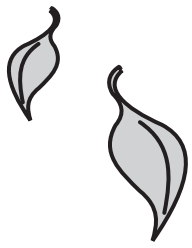
Comments: Remove and destroy (by chipping or burning) infested trees by early July before adult moths emerge. Control also may include targeting the larvae, spraying either acephate or dimethoate in early to midspring. Make two or three applications at 10- to 14-day intervals. Permethrin also may be used.

■ Pest: **Pine needle scale**
(*Chionaspis pinifoliae*) family Diaspididae

Host(s): Conifers. White spruce is the preferred host, but other hosts are Colorado spruce, various pines and Douglas-fir.

Description/Biology: Pine needle scales overwinter beneath the female scale covering as reddish eggs. Each female lays up to 100 eggs, which usually hatch in May or June. The tiny (1/80 inch) red crawlers or nymphs emerge and the wind disperses them to a new, uninfested host or they crawl to a new location on the same host. Young crawlers settle on the foliage, lose their appendages by molting and begin feeding. Nymphs become sexually mature in late July and August and the adult scales emerge. Female adults are wingless, while male adults have wings and are smaller. After mating, the female lays eggs until late October. She shrinks in size as she lays eggs.

Damage/Symptoms: Scales suck juices from the needles. Moderate populations can cause the foliage to become yellow and then turn brown. Heavy infestation can cause



branches and even whole trees to die. Symptoms include sickly looking trees with sparse, off-colored foliage and waxy white coverings over the scale insects. The scale cover looks like drops of white paint on needles.

Comments: Inspect ornamental trees for crawlers early in the spring. To manage most populations, keep hosts healthy and use timely applications of insecticidal oil or soap. Conventional insecticides, such as acephate and malathion, can be used; however, eliminating the scales' natural enemies with conventional insecticides can make the situation worse.

■ Pest: **Poplar borer**
(*Saperda calcarata*) family Cerambycidae

Host(s): Aspen, cottonwood, poplar, willow

Description/Biology: Adults, known as long-horned beetles because of their long antennae, are elongate in shape and grayish in color. Adults emerge from branches in late May to July and feed on the leaves of host trees. Females lay eggs in small holes gnawed through the bark, creating a U-shaped egg niche. White, legless larvae hatch in about two weeks and feed in the cambium before boring into the wood. A swollen, spindle-shaped twig gall results from the feeding wound. The larvae often are referred to as round-headed borers. The life cycle usually requires one to two years to complete, but it may take three years, depending on when the eggs were laid. Usually one or two adults complete development in each gall.

Damage/Symptoms: Larval feeding causes spindle-shaped twig galls to develop. When galls are numerous, the twigs easily break at the point of injury and normal tree growth characteristics are modified. Damage provides a point of entry for disease organisms, particularly the Hypoxylon canker fungus.

Comments: This insect attacks living trees but is more aggressive in weakened trees. See "Maintaining Healthy Trees and Shrubs." Remove low-value brood trees (where insects mate). Insecticide control is most often directed toward egg-laying adults and young larvae. Proper timing is critical. Insecticides labeled for borers include certain formulations of imidacloprid, permethrin, carbaryl and bifenthrin.

■ Pest: **Poplar bud gall mite**
(*Eriophyes parapopuli*) family Eriophyidae

Host(s): Cottonwood, poplar

Description/Biology: The mite is reddish and spindle-shaped. Mites overwinter in the galls. They become active in the spring and exit the old galls as buds are expanding, crawling over the surface of twigs and buds. They may have as many as eight generations in a season.

Damage/Symptoms: The gall is an irregular, lumpy, solid mass of plant tissue. It develops on one side of the twig and eventually encircles the base of the bud or shoot. Young galls are greenish; older galls are red to brown and corklike. Old galls persist for several seasons.

Comments: Although trees seldom are killed, lower branches often become crooked or stunted and may be killed. Continuous attack may weaken a tree, increasing its susceptibility to drought, frost or other injuries. Heavy infestations are very unsightly. If chemical control is necessary, spray carbaryl as buds and leaves are expanding in the spring. See "Mites (gall, rust, bud and blister)."

■ Pest: **Poplar petiole gall aphid**
(*Pemphigus populitransversus*) family Aphididae

Host(s): Cottonwood and other ***Populus*** spp.

Description/Biology: The aphids overwinter as eggs laid on ***Populus*** spp. twigs. They hatch as the tree foliage develops. The newly hatched nymph feeds on a leaf petiole, stimulating growth of a gall. The small, dark-colored aphids are found inside the round, hollow galls. These aphids secrete a white, waxy material that coats their body. After two weeks, the females bear live young that mature into winged females. These females leave the gall and find plants in the mustard family. They produce a generation on the alternate host. In the fall, the winged aphids return to ***Populus*** spp. and produce a male and female generation. Each female then produces one egg.

Damage/Symptoms: Round, hollow galls form on the leaf petioles. Several species of ***Pemphigus*** aphids occur in the region. Infested leaves may drop prematurely in late summer. They are not a serious problem on ***Populus*** spp. and control is not necessary for these species. The aphids may be a serious pest of the alternate hosts, which include crops such as sugar beets, lettuce and mustard.

Comments: See "Aphids (general)."

■ Pest: **Prairie tent caterpillar**
(*Malacosoma californicum lutescens*) family Lasiocampidae

Host(s): Hardwoods, chokecherry is the preferred host

Description/Biology: Adult moths are similar to ***M. americanum,*** the eastern tent caterpillar, and only an expert can identify them properly. Egg-laying habits are the only indicator to differentiate the species in the field. ***M. americanum*** have rounded egg masses that encircle twigs, while egg masses of ***M. californicum lutescens*** do not encircle

twigs and are deposited near the bases of hosts in the ground. They produce one generation annually and it overwinters as fully developed embryos in eggs. Larvae hatch in early spring, usually coinciding with flushing of their host's foliage. The fully mature larvae (2 inches long) have black backs with a white mid-dorsal line and light blue sides. Larvae live in colonies in large silk tents in forks of trees. After feeding, larvae spin silken cocoons in folded leaves, bark or litter, and adult moths emerge in midsummer. Adult moths are yellowish brown, medium-sized (1 to 1½ inches wingspan) and stout bodied, with a hairy body, legs and eyes. Two oblique whitish bands run across the forewings.

Damage/Symptoms: This is the most common species of tent caterpillars. The larvae cause defoliation. The protective webs are conspicuous and unsightly.

Comments: Larvae feed outside of the web nest, which makes control with insecticides easy. Bt works well to control young larvae, while pyrethrins or synthetic insecticides are needed for older caterpillars.

■ Pest: **Red-headed ash borer**
(*Neoclytus acuminatus*) family Cerambycidae

Host(s): Ash, elm, hackberry, linden, oak

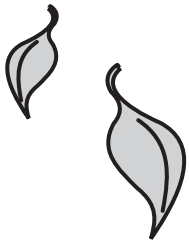
Description/Biology: They usually produce one generation per year. The adult overwinters in trunks and begins to emerge in April. Adults are about 1/4 to 2/3 inch long and reddish brown with three yellow transverse bands on the elytra. Females lay eggs on weakened or newly planted ash trees. The larvae bore into the inner bark and summer wood, disrupting the flow of sap.

Damage/Symptoms: Young trees infested with the red-headed ash borer are susceptible to breakage during high winds. Larvae bore into sapwood of live trees and cause serious damage to ash logs left in woods or logs stored with their bark attached.

Comments: Healthy trees are rarely attacked. See "Maintaining Healthy Trees and Shrubs."

■ Pest: **Scurfy scale**
(*Chionaspis furfura*) family Coccidae

Host(s): Ash, aspen, cotoneaster, elm, linden, other hardwoods



Description/Biology: The dirty white female scales are pear-shaped and 1/8 inch long. The scurfy scale overwinters as purplish eggs beneath the female shell. The purple crawlers hatch in late spring. The crawlers move away from the mother's shell and begin feeding on the bark. They probably produce only one generation per year.

Damage/Symptoms: When infestations are large, the dense numbers of scale give the bark a rough, ugly appearance. Large infestations reduce the vigor of trees. Infested branches and limbs may die.

Comments: Prune and destroy infested branches when practical. Treatments with summer sprays of oil or soap should be directed at controlling the crawlers when they are observed emerging from under the shells. Acephate or malathion will kill crawlers; however, these chemicals also will kill natural enemies of the scale insects and ultimately could make the infestation worse.

■ Pest: **Spider mites**
family Tetranychidae

Host(s): Wide variety of hardwoods

Description/Biology: Mites are very tiny and very diverse, so only an expert can make a positive identification. Spider mite adults have eight legs and tiny globular bodies that are translucent or colored. The life cycle of different species of spider mites is similar. Most mites pass through an egg stage, a six-legged nymph stage and then an eight-legged adult stage. A complete generation can be completed in two weeks at moderate temperatures. Mites usually overwinter as eggs or adult females on bark or leaf litter. Mite populations increase under hot and dry weather conditions and decrease under high humidity and wet-weather conditions.

Damage/Symptoms: Mites puncture the plant cells with their mouthparts and suck the fluids. Injured foliage is stippled, yellowed and eventually may turn brown and dry. A fine webbing on foliage indicates the presence of spider mites. A prolonged heavy infestation can cause slow plant growth, leaf drop and death of young plants.

Comments: To confirm mite infestations, hold a white piece of paper under leaves and sharply tap the foliage to dislodge the mites. Mites will be moving dots on the

paper or they'll stain the paper red when crushed. Mites often prefer the lower leaf surface, so be sure to inspect the undersides of leaves. Summer sprays of oil or soap may be used. Some dicofol and spinosad products are labeled for two-spotted spider mites; however, these chemicals also will kill natural enemies of the mites and ultimately could make the infestation worse.

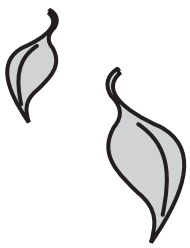
■ Pest: **Spruce needleminer**
(*Endothenia albolineana*) family Tortricidae

Host(s): Spruce

Description/Biology: This insect produces one generation per year. It overwinters in the larval stage. In late May to late June, adults emerge from the puparium. Adults are small, brownish gray moths (½-inch wingspan) with three irregular white bands on their forewings. Adults lay eggs on needles. Larvae bore into the needles in mid-June or later. Each mine usually has only one larva. Larvae are greenish in color with dark brown heads and about 1/3 inch long. When fully mature, larvae will spin groups of needles together to form silken nests for overwintering.

Damage/Symptoms: Larval mining kills the needles. Infested trees acquire a brownish cast. Severe infestations can result in up to 85 percent mined needles.

Comments: This insect usually causes only minor injury in North Dakota. Nests can be dislodged with a strong jet of water or by hand in the spring before buds swell. Carbaryl is labeled for spruce needleminer; however, spray timing in North Dakota is not well-understood. Sprays should be targeted at larvae as they emerge from eggs and begin feeding.



■ Pest: **Spruce spider mite**
(*Oligonychus ununguis*) family Tetranychidae

Host(s): Arborvitae, Douglas-fir, juniper, spruce, occasionally pine

Description/Biology: Adults range in color from green to pink to brown, are smaller than the size of a fine pepper flake and feed mostly on older needles. These mites overwinter in the egg stage. Larvae hatch from the eggs in late April or May and feed on the needles. The larvae are pink and turn green after feeding on the foliage. Larvae have three pairs of legs and are oval. After three days, larvae molt to the nymphal stage. The nymphs have four pairs of legs and are light to dark green in color. Nymphs transform into adults after six days of feeding. The wind can disperse the larvae and adults. Females live for about a month and lay 40 to 50 eggs. The complete life cycle of egg to adult takes only two to three weeks, depending on the temperature. A total of six or more generations may occur in a summer. Spruce spider mites are "cool season" mites. If temperatures consistently remain above 90 F, these mites will lay eggs and become dormant. They lay overwintering eggs from early September until frost.

Damage/Symptoms: The spruce spider mite produces a webbing around the needle base; however, this webbing may be difficult to see. Symptoms of feeding are a speckling or bleaching of affected foliage. Damage often is noticed on hot, dry summer days when injury from spring feeding becomes evident under the drying conditions. As a result of a heavy mite infestation, the needles may turn brown and later fall off. Severe infestations may kill branches or trees, especially during periods of drought.

Comments: Population buildups are most common in the spring and fall. Syringing and chemical controls can be used in controlling spruce spider mites. Spraying foliage with a forceful jet of water (syringing) can be an effective method for controlling mite populations in home landscapes while maintaining natural predators. Insecticidal soaps can be used to manage spruce spider mites in warm weather, while horticultural oils (1 percent to 2 percent rate) may be used during the summer, and dormant oils (3 percent to 4 percent rate) can be used to kill mite eggs and adults during the spring and fall. Horticultural oils can injure conifers if applied when temperatures are not appropriate. Read labels carefully. Dicofol or spinosad may be sprayed when adults are active, with a follow-up spray seven to10 days after the first spray to control later hatching nymphs.

■ Pest: **Uglynest caterpillar**
(*Archips cerasivorana*) family Tortricidae

Host(s): Chokecherry and other hardwoods

Description/Biology: It produces one generation per year. The uglynest caterpillar overwinters in the egg stage. Eggs hatch in the spring. Caterpillars feed for three to four weeks. The caterpillars have yellowish bodies with dark brown or black heads, thoracic shields and anal shields. They have a brown spot at the base of the body hairs. Mature caterpillars are 1 inch long and are a darker, yellowish green. Moths are active from late June to early September. The adult moths are 1 inch long with dull reddish orange-colored heads and forewings. The hindwings are bright orange. They lay eggs in masses on the bark of host plants.

Damage/Symptoms: Chokecherry is the most common tree that the uglynest caterpillar infests. The caterpillars are gregarious, living in a silk-covered nest spun to enclose the ends of branches. The nests become littered with frass and are unsightly on ornamental plantings.

Comments: The silk nest provides protection to the caterpillars. To control the caterpillars, prune out unsightly webs. If insecticides are used, treat early before nests become well-established.

■ Pest: **Variable oakleaf caterpillar**

(*Lochmaeus manteo*) family Notodontidae

Host(s): Bur oak, other hardwoods

Description/Biology: The caterpillars overwinter in earthen cells, pupating in the spring. Adult moths emerge in early June, laying single eggs on leaves. The caterpillars feed for five to six weeks, then drop to the ground. The full-grown larvae reach a length of about 1½ inches. The caterpillars vary in color but at maturity they are yellowish green with a reddish brown band bordered by yellow stripes running down the back. The head has black and white curved bands on each side.

Damage/Symptoms: Caterpillars defoliate trees. Outbreaks can be locally severe. When outbreaks occur for several years, trees may die. Outbreak populations usually collapse after two or three years.

Comments: Foliage may be sprayed with acephate or carbaryl when caterpillars are small. These insecticides will kill predators and parasites that feed on variable oakleaf caterpillar eggs and larvae.

■ Pest: **Woolly elm aphid**

(Eriosoma americanum) family Aphididae

Host(s): American elm, juneberry

Description/Biology: Woolly elm aphids alternate between elm trees and juneberry bushes, with different generations occurring on specific hosts at separate times of the year. Aphids overwinter as eggs beneath bark crevices of elms. In the spring, when the elm leaves are unfolding, the egg hatches into a wingless female that moves to the underside of a leaf to feed. Mature females give birth on the elm leaves to as many as 200 young. These offspring develop into winged females that migrate from elm to juneberry bushes. Migration begins by the end of June and occurs during a period of about 30 days. They produce another generation of females on the juneberries. These aphids crawl down the branches and trunk to the roots, where they produce several generations of orange-red aphids. They produce a generation of winged females and males in the fall. These aphids return to the elm trees and mate, and the females lay eggs that survive the winter.

Damage/Symptoms: The generation of aphids that is born on the leaves of the elm trees form dense colonies that cause the leaves to curl over them, providing protection from wind and rain. A mass of white, hairy insects can be seen if the leaves are uncurled. Damage to individual elm leaves can be severe, but infestations rarely occur on more than a few scattered branches, so the overall health of elm trees is not affected. However, aphids can cause an extensive amount of root damage to juneberry plants. This damage is not easily visible. Aboveground symptoms of woolly elm aphid damage are similar to general root damage – stunted plants that produce small leaves. Fruit production may not occur on heavily infested juneberries. Juneberry plants, especially those less than three years old, occasionally die as a result of heavy infestations.

Comments: Severity of infestations on juneberries may vary in relation to the density of, and distance to, the nearest American elm trees. Infestations on juneberry plants generally are more severe during the second year after transplanting, instead of the establishment year. Insecticides that are available for treating aphids on nonfruit-bearing ornamentals are not labeled for use against woolly elm aphids on juneberries, which do produce edible fruit. These aphids colonize roots, which poses additional management challenges. The only registered insecticides for use on juneberry (against woolly elm aphid) are certain formulations of the active ingredients thiamethoxam or imidacloprid. However, effectiveness of these insecticides against woolly elm aphids has not been investigated thoroughly. Additionally, these insecticides require a minimum of 75 days after application before harvesting fruit. Based on the life cycle of the aphid and the timing of the juneberry growing season, this interval would not be met if these insecticides are used. Woolly elm aphid is not an important pest of elm trees

except in nurseries. Control of woolly elm aphid on elms is not practical and would not prevent substantial numbers of aphids from moving to juneberry plants.

■ Pest: **Yellowheaded spruce sawfly**
(*Pikonema alaskensis*) family Tenthredinidae

Host(s): Spruce, primarily a pest of shelterbelt and ornamental plantings

Description/Biology: Adult sawflies are not flies but stingless wasps. The insect is called a sawfly because the female's ovipositor has serrated teeth resembling a wood saw. Adults are reddish brown in color and 1/3 inch long. They produce only one generation per year. Sawflies overwinter as cocoons. In late May to mid June, adults emerge and mate and females begin to lay eggs. The female deposits a single egg at the base of a needle. Eggs hatch in five to10 days. Larvae are 1/8 inch when they hatch. Mature larvae are ¾ inch long and dark glossy green with a light lateral stripe and reddish brown head. Larvae feed for 30 to 40 days, consuming the new foliage first and then the older needles. When mature, larvae drop to the ground and spin cocoons for overwintering.

Damage/Symptoms: Larval feeding causes defoliation. Heavily infested trees appear ragged, especially near the top, and can be completely stripped of foliage. Severe infestations over one to several years can kill trees directly or make trees susceptible to attack by other insects or adverse weather conditions.

Comments: Open-grown trees that are five to nine years old (3 to 18 feet tall) are more vulnerable to yellowheaded spruce sawfly damage than older trees or trees in dense stands. Although rodents will feed on the prepupae and birds on sawfly larvae and adults, these predators, in addition to various parasites, are not always effective in keeping yellowheaded spruce sawfly populations at acceptable levels. If infestations are light, simply removing young larvae by hand may provide adequate control. When an isolated ornamental tree is infested, spraying young larvae off of the tree with a strong jet of water often will be effective in reducing insect numbers. Yellowheaded spruce sawflies tend to attack the same trees repeatedly; therefore, chemical control often becomes necessary as sawfly populations increase. Acephate and carbaryl are labeled for use against sawflies. Since most yellowheaded spruce sawflies are believed to overwinter very near the soil surface, removing the duff beneath infested trees may reduce the impact of this insect.

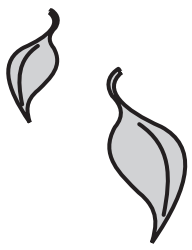
■ Disease: **Apple scab**
(*Venturia inaequalis*)

Host(s): Apple, crabapple, mountain-ash

Description/Biology: This fungus survives the winter in leaf and fruit debris that falls from the tree. Under appropriate environmental conditions in the spring, the fungus produces primary spores that infect young leaves and fruit. Secondary spores produced on diseased tissue infect other leaves and fruit. The secondary spores may have multiple generations per season if appropriate environmental conditions persist.

Damage/Symptoms: The fungus causes olive green to brownish velvety lesions on fruit and leaves of the host. On the fruit, lesions often are corky and brown, and may cause disfigurement. Lesion diameter averages ½ inch, but they may coalesce and appear larger.

Comments: Clean up and destroy fallen leaves and fruit. Protectant fungicides, including chlorothalonil, propiconazole, thiophanate-methyl, myclobutanil and mancozeb, can be used during prolonged wet weather. Resistant crabapple cultivars, including, Centurian, Donald Wyman, Prairiefire and Spring Snow, are available. Dense foliage, nearby susceptible trees and protected sites favor development of apple scab. Prune branches from a tree to reduce leaf density and allow more air movement to favor reduced disease severity. Remove highly susceptible trees and do not



Disease Management

Disease Diagnosis and Management

As stated in the General Insect and Disease Management section, woody plant health problems have many causes, most of which cannot be covered in this publication. This section deals primarily with biotic diseases, those that plant pathogens cause. Some general guidelines can be applied to disease management even when a specific diagnosis of the problem is not made. In this general section, these are discussed by the type of disease involved, i.e., foliage diseases, canker diseases and stem decays.

All woody plant species have some pathogens that cause diseases in each category. A search of references or the Internet usually will provide some information about particular diseases. However, some pathogens are rare and reports about them are difficult to find. New pathogens are being found. Pathogens are being moved at a seemingly increasing rate into new regions from nearby states and distant continents. Their behavior in North Dakota may be quite different from other areas because of differences in host genetics and environmental conditions. However, gathering enough information from the literature or by observation to gain a basic understanding of the problem and to develop some likely effective disease management options usually is possible.

■ Foliage diseases

Description/Biology: Foliage diseases primarily affect only the leaves. Fungi cause most biotic foliage diseases of woody plants in the northern Great Plains, but some bacteria and viruses also cause foliage diseases. In addition, insects, air pollutants, chemicals and environmental factors can cause symptoms that are similar to those that pathogens cause.

After infecting a leaf, a foliar pathogen grows to colonize part or all of it. Most pathogens eventually cause a portion of a leaf to die; the dead area is called a lesion. Fruiting structures of fungal pathogens, in which spores are produced, usually develop within the lesion. Some foliage diseases have multiple infection periods within a single growing season (e.g., apple scab, powdery mildews). Others have a specific season during which infection can occur each year, but infective spores are not produced from those infections until subsequent seasons (e.g., Rhizosphaera needlecast, leaf curls).

Fungal pathogens of foliage most often overwinter in diseased foliage, either on the ground or on leaves that remain attached to branches through the winter. Pathogens that cause foliage diseases, especially those that cause anthracnose, also may overwinter on other plant parts, such as in twig and branch cankers (e.g., ash and oak anthracnose, fire blight), in reproductive structures such as seeds and seed stems (e.g., ash anthracnose), and in bud scales (e.g., leaf curl). Those pathogens that grow from the leaf into a limited portion of branch (locally systemic) can overwinter in those branches (e.g., juneberry black leaf). Those that have life cycles of one year or more overwinter in foliage that may or may not show symptoms (e.g., Rhizosphaera needlecast, Lirula needle blight). Rust fungi that cause foliage diseases generally overwinter as the cold-hardy spore stage (teliospores) in dead leaves or branch infections of the same woody plant species or in another woody or non-woody host of the pathogen. Some pathogens overwinter in multiple ways.

Foliage pathogens may reach the infection site through several means, the most common of which are passive dispersal by rain splash or wind blowing spores from fruiting

bodies on infected plant parts (e.g., anthracnose fungi, leaf-curl fungi, needlecast fungi, mildew fungi, rusts, fire blight bacteria). Other means include active dispersal by insects (e.g., fire blight, viruses) or by humans through mechanical means such as grafting (viruses) and pruning (fire blight).

Wet weather is conducive to the development of several foliage diseases due to exudation of spores from fruiting bodies, an increase in spore dispersal by rain splash or a requirement of free moisture on the leaf surface for spore germination and infection. Many fungi that require free moisture for infection need at least 12 hours for the process to be complete, and availability of free moisture beyond 12 hours tends to increase the number of infections that occur. In addition to direct effects on the pathogen, wet weather and ample soil moisture can result in increased foliage diseases if they cause increased shoot growth and more succulent leaves, which tend to be more susceptible to many foliage pathogens than slow-growing or mature leaves. The amount of infection can vary greatly from one growing season to another, depending on the amount of wet weather.

Damage/Symptoms: Foliage diseases can appear as distortions, mosaics, distinct spots, indistinct blotches, or general death of individual or masses of leaves. Rusts will cause distinct spots and fruiting bodies that are yellow to orange during the growing season. Symptoms vary by both host species and pathogen. Sometimes, leaves will die or fall following only one infection. At other times, the leaves may remain attached and living even after numerous infections. In general, the more spots or blotches the leaves have, the less food they will produce to supply the plants' food reserves.

On an initially healthy plant, defoliation greater than 25 percent to 50 percent generally is considered "substantial." Defoliation and subsequent refoliation draws down food reserves within the tree. When substantial, this results in shorter shoots and smaller leaves. Several years of such defoliation may draw down food reserves to the point where twigs and branches begin to die back. This dieback starts at the top on deciduous trees and also may result in formation of epicormic branches (also known as water sprouts). On conifers, dieback begins at the bottom of the tree. Conifers are more sensitive to defoliation than deciduous trees.

The patterns of symptom occurrence and development are keys to discerning if a foliar pathogen or some other agent damaged the leaves. Foliage infections tend to occur in a random pattern on leaves in a given area. If spots occur uniformly within the leaves or among leaves, then the cause is less likely to be a foliage pathogen. If all the leaves on individual twigs, branches, stems or entire trees develop similar symptoms at the same time or progressively down the plant, then the problem likely is not a foliar pathogen. A canker, insect activity, hail damage or lawn mower damage can affect individual twigs or branches, resulting in dead or damaged leaves. The further down the plant the damage occurs, the greater the proportion of the crown that is affected.

Other patterns can help discern if a problem is due to foliage diseases. Because wet leaf surfaces generally result in increased infection, portions of the plants that stay wet longer often have more disease. This tends to be the lower portion, the shaded side, the wind-protected side or the watered side of the crown. Thus, if leaves on one side of the plants are affected, but that is not the side that is wetter, the cause may be something other than a foliage pathogen, e.g., scorch if on the sunny side, herbicides drifting from that side or winter injury of conifer needles in portions of the crown that were exposed to winter winds and direct sunlight.

Comments: Generally, three types of management are available — cultural, chemical and genetic. With cultural control, some aspect of growing the trees is managed to reduce the threat of serious infection. For example, planting, thinning or pruning the plants to allow more air movement around and through them tends to reduce the amount of infection by foliage pathogens by allowing leaves to dry off more quickly after rain, morning dew or unintended watering while irrigating the lawn. Watering should be done after morning dew has already evaporated but early enough so the sprinkler water evaporates before nightfall. Reducing the amount of inoculum (source of infection, usually spores) can reduce the amount of infection. Spacing woody plants far enough apart so the pathogen has more difficulty spreading from one plant to the next also can reduce disease development. The exact distance varies by pathogen. Planting other kinds of trees and shrubs between plants that are susceptible can serve as a barrier for rain-splashed and windblown spores spreading from one plant to the next. Mulching or tilling fallen, infected leaves can reduce the amount of inoculum that can return to the plant. When planting trees and shrubs where infections exist, plant different species that are not susceptible to the existing pathogens.

With chemical control, a pesticide is used to prevent infection by or eradicate the pathogen **at some key part of its**

life cycle. Pesticides are registered for management of most foliage diseases, but determining what pesticides are registered and the proper application schedule, and even finding a source for a particular pesticide for unusual diseases, sometimes is difficult. The sources of expertise listed in the section "General Insect and Disease Management" often can help provide such information, and an Internet search may be helpful. Using a pesticide that is labeled for a particular disease with the proper application schedule is especially important. Use pesticides only for those disease-host combinations that are listed on their labels. Also, pesticides must be applied with correct timing; otherwise, they will not give optimum control.

Knowledge of how a particular disease has developed is important in helping decide if pesticide applications are appropriate. If a disease has caused substantial damage in the area, then a serious potential may exist for future damage. Because this is not always the case, simple identification of some pathogens does not mean that damage will occur. Much depends on weather patterns, so a disease that develops to a serious level in one season may not in another season. Therefore, wait to see if conditions are conducive for disease development before making pesticide applications.

With genetic control, plants that are resistant to a particular pathogen are used to prevent or reduce damage. In general, few of the woody plants available in North Dakota have been selected for disease resistance. However, some possibilities are available, e.g., poplar cultivars that are resistant to Melampsora leaf rust or spruce species that are more resistant to Rhizosphaera needlecast than others. Favor increased genetic diversity whenever possible. If too many plants of a single species are present in a given area, a disease can increase quickly to a serious level and damage a high proportion of that species. Alternating two or more species in ornamental or conservation plantings can reduce disease development substantially on any one of those species. Avoid planting alternate hosts of rust pathogens in the same vicinity. This primarily applies to cedar-apple rusts, which alternate between junipers (***Juniperus*** spp.) and plants in the apple family (e.g., apples, crabapples, juneberry, hawthorn).

■ Cankers

Description/Biology: Cankers are dead areas on the outside of branches or stems. They can be superficial on the outside of the bark or extend into the wood. Most commonly, they are associated with death of the cambium and result in discoloration and collapse of the bark in the cankered area. The margin of the canker expands as the pathogen grows into live tissue. If the bark is thick, it may not collapse or discolor. In such cases, the canker may be visible only if the bark is removed or the area outside the canker grows, resulting in a sunken area. Some canker pathogens tend to cause infection and canker growth during certain seasons (e.g., spring, growing season, dormant season), while others expand during most of the year. Some are considered annual cankers that require a new infection each year to form a canker, while others are perennial, expanding periodically or continuously over multiple years.

Fungi and bacteria cause cankers. The pathogens may be host specific, that is, infect only certain woody plant species, or they may have a broad host range. The pathogens tend to be weak parasites and often can survive in dead bark as saprophytes (organisms that live in dead and decaying organic matter). Complicating the issue, canker pathogens may infect branches dying from other factors. They then may remain restricted to the dying area or expand beyond the dying area.

Pathogens that cause cankers generally overwinter in cankered tissues on branches and stems. Some also overwinter on fallen leaves and in bark of branches that died of other causes. They generally infect trees through wounds and cause greater damage to trees under stress. Some of these pathogens infect healthy bark and reside there as latent (inactive) infections; such infections allow the pathogen to colonize branches rapidly if they become stressed or begin dying. Branches and limbs die as the expansion of the cankers girdles them. For fungal canker pathogens, small fruiting bodies usually develop in or on the bark of cankered areas, from which spores may be dispersed to other branches to cause new infections. Fruiting bodies may develop in the same season as the initial infection or as long as several years later. Bacterial canker pathogens do not produce fruiting bodies. Bacterial cells ooze onto the infected bark surface, from where rain splash, wind, insects and other means disperse them. Dispersal may occur in the same season as infection, the following season or both.

Some wounds and stresses commonly associated with increased canker development are drought, hail wounds and herbicide injury. Other situations that can increase canker development include excess shading of lower branches, standing or excess water, lack of cold hardiness, defoliation, damage to the stem or root system, ice damage, pruning wounds and openings in the bark that insects cause. Once a tree becomes infected, it initiates defense mecha-

nisms to try to stop canker development. The success of these mechanisms is increased in plants with higher vigor, so encouraging high plant vigor or removal of stressing factors helps the plant defend itself. One exception to this is for fire blight cankers (page 39). In general, the plant defenses reduce growth of the cankers, allow development of callus at the canker margin or stop canker growth where the infected branch joins a larger branch.

Damage/Symptoms: The canker symptoms that usually are noticed are individual branches with wilted, discolored or dead leaves or individual dead branches without leaves. On a branch with an active canker, expanding areas of discolored bark extend out from the point where the canker originated. If the canker pathogen is in the inner bark or wood, peeling back the bark may reveal discolored plant tissue. However, the cankered area of some (e.g., fire blight) may be difficult to see during some parts of the year. As infected tissues die, the discolored area often becomes sunken. Cankers also may develop from pathogen invasion of dead or weak branches, twigs and fruit spurs. Individual branches or entire trees may be killed. The canker may continue to grow down the branch onto larger branches until the tree's defenses or the canker's biological limits stop its expansion. Dead leaves often remain attached to branches that were girdled and died during the growing season. On larger branches and main stems, slow-growing perennial cankers (e.g., those that Nectria species cause) produce what are termed target cankers because of the concentric rings of dead wood in the canker after several years. Fruiting bodies of fungal canker pathogens may form on the surface of the bark (e.g., Tubercularia) and/or embedded in the bark (e.g. Botryodiplodia).

Twig or branch dieback that other factors cause, such as cold injury or stress, can be confused with cankers because they can result in death of the bark to a specific point bordered by a raised margin, similar to the injury caused by cankers.

Comments: Positive identification of most canker pathogens requires laboratory examination, but some can be identified based on signs and symptoms in the field. However, their presence does not always establish their role as pathogens; they may have invaded or fruited on the dead tissue after something else killed it.

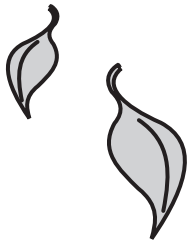
Because stress increases the risk and severity of canker problems, help woody plants avoid or reduce stress to reduce occurrence and severity of cankers. Selecting woody plants that are adapted to site conditions can help assure vigorous growth. Some woody plant species tend to be prone to canker diseases. These generally include fast-growing or marginally hardy species such as aspen, cottonwood, poplars, willows, Siberian elm, Siberian pea shrub (caragana), American plum, cotoneaster, honeylocust, Colorado blue spruce and Russian-olive.

Once cankers develop, treatment options are limited. Fungicides generally have not been effective in managing cankers. The direct treatment of choice is proper removal of the cankers and destruction of the tissue that was removed. This usually involves pruning the branch below the canker. Some cankers, particularly those that bacteria cause, should be pruned well below the discolored or cankered area because the pathogen may be located far beyond where the canker is visible. If cankers occur on larger branches or the main stem, removal of the diseased branch or stem will cause great damage. In these cases, consider removing the plant. Excising cankers from a stem or branch sometimes is possible. To do so, use a sharp knife to cut through the bark to the wood. Generally make the cut at least 2 inches beyond the margin of the discolored bark associated with the canker. Then remove all the bark within the cut. The removed area should be diamond shaped, preferably with the sides of the diamond somewhat rounded, but with the top and bottom pointed.

Pruning tools should be disinfected between cuts to avoid spreading the canker pathogen. If in doubt about whether pruning tools are contaminated, disinfect them in denatured alcohol or a 10 percent bleach solution. Prune in early spring as the cambium becomes active, but before the leaf and flower buds open, to reduce the threat of new infection. Pruning at this time will allow rapid callus development on the wounded tissue while the inoculum potential of canker pathogens is relatively low.

■ Stem decay

Description/Biology: Fungi cause stem decay. Most decay fungi are relatively host specific, but some infect several host species. Stem decay has been observed in all major



woody plant species in North Dakota and many minor ones. Aspen, boxelder, buffaloberry, bur oak, caragana, cottonwood, green ash, plum and willow are particularly subject to stem decay in North Dakota. Spores that are deposited on exposed wood may cause infections if the condition of the wood and environmental conditions are favorable (usually warm and wet). The wood initially may be exposed because of wounds or through branches that died from shading, cankers or other causes. Tree experts think other microbes must colonize and modify the wood before most decay fungi can colonize it. The process and times required for such modifications are not adequately described or understood. Once decay fungi infect the wood, reasonably healthy plants can form barrier layers in response to infection. The barrier layers "wall off" the column of wood that existed when the plant first was infected (except when canker-rot fungi are present) and prevent the fungus from growing outside of that column. Any wood that develops outside of the barrier will be sound. However, if the infected trees are wounded or severely stressed, the fungus can escape from the contained area to invade other wood tissue, and the formation of barriers starts over. A continual change of balance may occur between the pathogen and the host with regard to where decay occurs.

Decay fungi may grow in wood for a few to many years before they cause substantial decay. As they grow and utilize nutrients in the wood, they break down cell walls so that the structure of the wood is weakened or destroyed. Such wood is referred to as decayed, punky or rotten. Once stem decay fungi have obtained an adequate food base from the decaying wood, they produce fruiting (spore-producing) structures to complete their life cycle. These structures grow on the outside of the wood or bark as mushrooms or conks (shelflike or rounded woody growths). Mushrooms produce spores in one season and then deteriorate, while conks may be annual or perennial. Perennial conks grow a new spore-producing layer each year. The wind disperses the spores to wounds or openings in the bark, thus continuing the cycle.

Damage/Symptoms: Branch and top dieback are common in trees with advanced decay, but determining whether the decay caused the dieback or whether stress allowed the decay to advance is difficult. The most obvious sign of decay in a woody plant is the fungal fruiting structure. Some decay fungi also cause cankers, or areas of dead bark adjacent to the decayed wood. Unless these signs or symptoms are present, determining if wood decay fungi infected a plant without examining the wood on the interior of the plant is not possible. When wood decays, it usually becomes soft and has a different texture, compared with sound wood. Depending on the fungus involved, the decay may occur in the heartwood (the central core of dead wood), sapwood (the outer wood) or both. Sapwood-decaying fungi usually are in the older, inner rings of sapwood rather than the most recent years' growth. Color of the decayed wood can range from white to yellow to dark brown. Trees that decay fungi have infected for a long time may be hollow. No single decay fungus uses all the wood components, so the hollows are most likely due to removal of decayed wood by carpenter ants, mammals or birds.

If a tree with mushrooms, conks or canker rot is in a location where it poses a hazard, have a professional arborist evaluate it to determine whether it remains structurally sound. If the tree has lost its structural strength, it should be removed. To estimate the amount of decay, take cores from the wood with an increment borer. Electrical devices are available to evaluate where decayed wood is present.

Comments: The best treatment against decay fungi is to maintain good tree vigor, minimizing wounds and other stresses, and allowing the trees to keep their own natural defenses at a maximum. Following proper pruning practices (page 6) is a critical part of this recommendation. Trees that develop from stump sprouts may get infected from the original stump if they become stressed or wounded while the old decay still is active.

Removal of trees with fruiting structures may be necessary to eliminate hazard risk. However, removal of a given tree with conks will not markedly reduce the chances for infection of nearby trees because spores from other infection sources can be dispersed over long distances.

plant susceptible species or varieties in areas where multiple susceptible trees already exist to reduce the likelihood of problems. Place susceptible species in open (sunny, open to wind) sites, or remove or prune other trees to provide those conditions to favor reduced scab infection.

■ Disease: **Ash anthracnose**
(*Gnomoniella fraxini*)

Host(s): Green ash, other ash species

Description/Biology: This fungus overwinters in fallen leaves and twigs and in rachises (long, central part of compound leaves), fruit and twigs that may be retained in trees throughout winter. Under wet conditions in the spring, spores that are produced infect succulent new growth. Cooler weather favors disease development. Dry weather reduces spore production and disease development. Leaves, shoots, twigs, branches and fruit are infected.

Damage/Symptoms: The classic symptom is brown, dead, distorted leaf tissue. These leaves may have brown blotches associated with leaf veins and they often fall prematurely. Small leaf spots with purple halos develop instead of blotches during less favorable weather, either warmer or drier conditions in early spring, or infections of older leaves later in the season. Either of the symptom types may cause serious defoliation, possibly leading to stunted growth and dieback in subsequent years. Defoliation later in the growing season is less damaging to tree health. Disease development often is not noticed until leaves begin dropping. Leaf drop may be enough to cover sidewalks and fill gutters. Orange or tan superficial lesions develop on infected twigs. These lesions may develop further into cankers and kill those twigs.

Comments: Raking and destroying fallen leaves may reduce infections in subsequent years, but this has not been demonstrated. Fertilizing to promote growth (high nitrogen) will allow for optimum refoliation, and informal observations indicate that trees receiving high nitrogen fertilization had relatively little disease during severe infection pressure. In areas where anthracnose repeatedly infects trees, protectant sprays may be necessary. Three applications work best, and timing of fungicide is critical for controlling disease development. The first application should be made as buds are beginning to swell, but before they break. The second application should be made when the buds show green tips, and the third fungicide application should be made when the leaves are half grown. The recommended spray treatment should be lime sulfur first, followed by two treatments with a chlorothalonil product. Spraying after first infection can reduce late-season infections.

■ Disease: **Ash rust**
(*Puccinia sparganioides*)

Host(s): Ash

Description/Biology: This fungus requires two hosts, ash and various species of cordgrass (***Spartina*** spp.), to complete its life cycle. ***P. sparganioides*** overwinters on grass species. Two rust spore types (spermagonial and aecial) occur on the ash in the spring and early summer. Aeciospores are liberated from the ash host and subsequently infect grass species, where the fungus overwinters. In the spring, the fungus produces another spore type (basidiospores) that will infect ash.

Damage/Symptoms: Infection can occur on all plant parts formed in the current season, but it is most common on leaves. The initial symptoms are yellow to orange spots on the upper leaf surface and chlorotic spots on other plant parts. About two weeks after the appearance of those spots, bright orange lesions containing aeciospores appear, breaking through the plant surface on the lower side of the leaf and on petioles and stems. These lesions may be from 1/16 to ½ inch in diameter and the pathogen causes swellings of ¾ inch or longer in petioles and stems. Diseased tissue may swell, causing distortion of leaves, sharp bends in petioles, and roughly egg-shaped galls on twigs and seeds. Severe defoliation occurs in some locations under optimum conditions, but tends to be serious mostly on individual trees near locations with the alternate host, such as swampy areas.

Comments: No control is needed on established trees, but may be desired for aesthetics. On trees subject to severe infection in areas where the cordgrass cannot be controlled (mowed, sprayed), fungicides such as myclobutanil may be used.

■ Disease: **Ash yellows**
Candidatus Phytoplasma fraxini

Host(s): Ash, lilac

Description/Biology: The disease this pathogen causes is called ash yellows in ash and lilac witches'-broom in lilac. Phytoplasmas are bacteria that survive in the phloem of plants and that phloem-feeding insects such as leafhoppers vector (carry). Once infected, hosts remain infected.

Damage/Symptoms: Symptoms vary, depending on the age of the tree, stage of disease, the tree's level of tolerance and the pathogen's level of aggressiveness. Some of the symptoms that may be present on infected ash include subnormal leaf size, lime-green leaf color, slow-growing lateral branches, witches'-brooms at the soil line or on the trunk, branch dieback or death of trees. Some symptoms that may be present on lilac include clusters of scorched leaves and witches'-brooms. Recent research has shown that ash yellows phytoplasmas are present in ash all over central North America and have been found in lilac in southeastern North

Dakota. We do not know if ash yellows or lilac witches'-broom cause significant damage in North Dakota, but the pathogen has been reported to cause decline and death of some infected ash in other states. Also, the pathogen can prevent recovery from stress that other factors caused.

Comments: Green ash is the most important tree species in North Dakota in urban plantings, conservation plantings and natural stands. The threat of serious insect or disease problems supports reduced reliance on green ash or any other single species in tree plantings. Nevertheless, continued but judicious use of ash and lilac is appropriate. If a plant is showing symptoms of ash yellows infection, good plant care principles, such as proper irrigation, fertilization and pest control, may prolong aesthetic qualities of infected trees. The usefulness of removing infected trees to reduce inoculum is questionable. Resistant cultivars have been identified in the eastern and central United States, including north-central Iowa. White ash generally is less tolerant than green ash. Ash cultivars Bergeson, Dakota Centennial®, Patmore and Autumn Applause were least affected. Evaluations are under way
to determine if certain cultivars used in North Dakota are more tolerant than others.

■ Disease: **Black knot**
(*Apiosporina morbosa*)

Host(s): Chokecherry, plum, other Prunus spp.

Description/Biology: This fungus overwinters in "knots" (conglomerations of fungal fruiting structures) on host twigs and branches. In the spring, spores produced in the knots may be windblown or rain splashed to new shoots or wounds in older branches, causing new infections. ***A. morbosa*** grows under the bark and in nutrient- and water-carrying vessels. Swellings may occur on infected twigs in the fall of the same season or during the following season. The swellings become knots by the second spring after infection, when spores typically are produced (two-year life cycle). In some situations, the life cycle can be three or more years long. The knots may die after their first sporulation, or they may live for many years and gradually extend several feet along old stems and branches.

Damage/Symptoms: The swellings initially are olive green in color, corky in structure and velvety in texture. They become black, rough and woody by the second winter after infection and become two to three times the diameter of healthy branches of the same age. The disease sometimes causes twigs to bend at the swellings, and branches may be killed above knots. Trees that are particularly susceptible or in a site where conditions favor heavy infection may have hundreds of knots. Trees with many infected limbs or infections on the lower stem may be severely stressed or (rarely) die, but heavily infected trees may live and grow well for many years.

Comments: Although some people recommend not planting chokecherry because of its susceptibility to black knot, control of this disease is a minor problem, compared with controlling chokecherry suckers. Removing the knots and 3 to 4 inches of healthy wood below the knots as they become visible usually controls the disease but needs to be repeated whenever new knots develop. Lime sulfur may be used as a dormant spray after removal of knots, or thiophanate-methyl may be sprayed when the tree is (1) dormant, (2) pink bud, (3) full bloom, and (4) three weeks after full bloom. This disease may be easy to manage if all sources of inoculum are controlled. This can be difficult in areas with many infected wild plants or neighbors who do not actively manage for the disease in their Prunus spp. ornamentals. Many individual plants are resistant to black knot, so control or removal of heavily infected plants will reduce disease pressure. The disease is not a widespread problem unless multiple years of weather favorable for infection occur.

■ Disease: **Black rot**
(*Botryosphaeria obtusa*)
(this fungus also causes frogeye leaf spot)

Host(s): Apple, crabapple, mountain-ash

Description/Biology: This fungus overwinters in bark scales, cankers, mummified fruit, and twigs and stems killed by other causes. It produces its first spores of the year in infected tree tissues in the spring and usually releases the spores after bud break, primarily by water. Spores can develop and be dispersed during cool (~ 70 F) wet weather throughout the growing season. Early infections occur in leaves and petals, while later infections occur on fruit through cuticular cracks. Black rot branch and stem cankers are caused as the pathogen enters wounds through the bark. These cankers often develop after winter injury to hosts.

Damage/Symptoms: Early infection of the floral parts may appear as soon as bud scales loosen. Sepal infections cause reddish specks that turn purple with a red border. This type of infection may result in blossom end rot in fruit later in the season or after harvest. Leaf infections appear as purplish flecks that enlarge to round lesions approximately 3/16 inch in diameter. As the disease progresses, the lesion margins remain purple while the centers become tan to brown (giving a "frogeye" appearance). Heavily infected leaves may become chlorotic and fall. Cankers (dark brown, sunken lesions) may develop on stems and branches. A canker may be only superficial on the bark or it may kill the bark and extend into the wood, weakening the limb and possibly resulting in breakage during heavy fruit set or snow

loads. Cankers tend to extend along the length of branches and stems rather than around them, and a canker may take several years to girdle a branch. When cankers do extend around branches, or when a canker grows from the base of a smaller branch around a larger branch, the leaves on the girdled or nearly girdled branch tend to turn bright yellow and remain attached for several weeks. Fruit infection will appear first as reddish flecks that develop into purple, raised bumps on the fruit. Infection on more mature fruit will appear as black, irregularly shaped lesions (blotches) with a red halo.
As these lesions enlarge, they can form concentric rings alternating between black and brown. Infections can grow at refrigerator temperatures, resulting in black, rotten areas in stored apples.

Comments: General sanitation measures that include cleaning up leaf debris in the fall, removal of mummified apples, and pruning out cankers and dead wood while trees are dormant will help control this disease. On older trees, black rot cankers (both superficial and bark killing cankers) often are too numerous or long to remove without destroying the tree. In such cases, when the cankers develop to the point that branches produce sparse foliage, the damaged portions should be pruned out. Practices
that improve the health of the tree should be applied. See "Maintaining Healthy Trees and Shrubs." Fungicides rarely are necessary.

■ Disease: **Botryodiplodia Canker**
(*Botryodiplodia hypodermia*)

Host(s): Elms

Description/Biology: This fungus overwinters as cankers and primarily attacks stressed branches or whole trees, invading through wounds. Spores are produced in fungal fruiting structures in the cankers all season long and wind and rain splash spread them, but damage is most severe when infection occurs during the spring.

Damage/Symptoms: Cankers develop on twigs, branches and trunks and may girdle them in a single season. In newly infected bark, tissue appears water soaked, soft and reddish brown to brown. Foliage may yellow, wilt and die beyond the cankered area. On Siberian elm, cankered bark may slough off and leave obvious scars, and the wood under cankered bark often is very dark brown. Leaves on American elms may turn bright yellow in mid to late summer and shed prematurely. This symptom often is confused with Dutch elm disease.

Comments: Maintain good general health of trees, especially providing adequate water since drought-stressed trees are more susceptible. See "Maintaining Healthy Trees and Shrubs." Phenoxy herbicide exposure also has been associated with increased damage from Botryodiplodia canker. Avoid wounding trees. Remove cankered and dead wood from trees. No chemical treatments are available.

■ Disease: **Brown rot**
(*Monilinia fructicola*)

Host(s): Plum, other stone fruits and some pome fruits

Description/Biology: This fungus overwinters in mummies (dried, infected fruit) on the tree and on the ground and in twig cankers. In the spring, it produces spores that the wind, rain splash and insects carry to blossoms, young leaves and shoots, where new infections occur. ***M. fructicola*** is not active during the summer but will infect ripening fruits in late summer and fall. Disease development is rapid in warm, wet and humid weather.

Damage/Symptoms: Newly infected succulent shoots often droop at the infection site, causing symptoms that may be confused with shepherd's crooks, which fire blight causes. With brown rot, the shoot and leaves are at first gray and fuzzy due to the presence of the fungus on the surface of the dead tissues. The leaves and shoots later become light brown. The most obvious symptom is the brown rot that occurs on the fruit. On green fruits, this is characterized by small, round, light brown spots. On ripening fruit, pale, ash gray to brown, feltlike fuzzy masses of spores cover fruit. Fruit will rot in hours during wet weather. Rotted fruit may cling to the tree or fall to the ground. Brown rot may develop on fruit in storage.

Comments: Management for brown rot should begin in late summer and fall. Remove all remaining fruit, mummies and cankered twigs. Remove or bury mummies before blossom. Fungicides such as captan and thiophanate-methyl may be used for controlling infection. For captan, the first application should be made as soon as blossoms show color. When the weather is wet and night temperatures are above 55 F, apply the second spray at full bloom and the third spray at petal fall. Another application should be made when green fruits are fully developed but have no color. Repeat the application 10 to 14 days later if the weather is humid and temperatures are 60 to 80 F.

■ Disease: **Cedar-apple rust**
(*Gymnosporangium juniperi-virginianae* and related species)

Host(s): Rosaceae (apple, crabapple, hawthorn, juneberry), juniper

Description/Biology: These fungal pathogens require two different hosts to complete their life cycles. They overwinter as galls or witches'-brooms on junipers. In wet weather, orange, gelatinous spore-bearing structures develop. These

structures can develop several times between May and August, producing spores each time that can infect Rosaceous hosts. Yellowish-orange lesions develop on leaves and fruit of infected Rosaceous plants. Juniper-infecting spores develop in these lesions. New infections on junipers will release Rosaceous host-infecting spores either the following spring or the year after. The galls or witches'-brooms of some types are perennial, producing spores each year for a few to many years.

Damage/Symptoms: On Rosaceous hosts, infection results in small yellow-orange lesions on the upper surface of leaves and young fruit. The infections expand to the lower leaf surface, where they form 1/16- to 3/16-inch diameter orange pustules. Damage to Rosaceous hosts may develop as reduced fruit quality and minor to almost total defoliation of susceptible cultivars. New infections on junipers result in small galls or witches'-brooms that gradually enlarge until sporulation occurs. Even high gall pressure usually does not damage Junipers, but their appearance is unsightly. Witches'-brooms damage the function and appearance of infected trees.

Comments: Remove one of the alternate hosts (juniper or Rosaceae) if it is not a desired plant. If removing an alternate host is not possible, picking the galls or pruning the witches'-brooms off the junipers may keep the disease to a manageable level. Chlorothalonil, fenarimol, mancozeb, maneb, myclobutanil, propiconazole, thiophanate-methyl and triadimefon are labeled for some ornamental Rosaceous hosts. Check hosts listed on any products before purchasing. They should be applied at a regular interval as indicated on the label or when the orange spore-bearing structures develop on junipers. The crabapple cultivars Donald Wyman, Indian Magic, Indian Summer and Prairifire are resistant to cedar-apple rust.

■ Disease: **Cytospora canker of spruce**

(*Leucostoma kunzei* = [*Cytospora kunzei*])

Host(s): Spruce

Description/Biology: This fungus overwinters in the bark of infected branches. Spores may be released any time temperatures are above freezing. Infections occur in wounds or cracks in the bark. The fungus expands and kills the bark. It continues to grow until the branch is killed. Fungal fruiting bodies develop in the dead bark to produce more tree-infecting spores.

Damage/Symptoms: Individual branches die back, usually in the spring and typically beginning in the lower crown. Often, sap oozes from the cankered area and dries on the infected branch and branches immediately below. The most characteristic symptom is the presence of individual dead branches; the cankers rarely grow into the main stem in this region of the country. As a branch is dying, the needles will discolor, first to a dull green and then to purple or brown before they drop off. If infected limbs are left on the tree, other branches on the tree more likely will be infected in subsequent years, and the disease may cause the tree to lose aesthetic, wind control and noise reduction benefits. Severely affected trees eventually may die, but usually are removed before then because of the loss of value.

Comments: Allow plenty of space between trees, maintain good plant health and avoid wounding. Prune out and destroy infected branches as soon as they are observed (best done during dry weather) or in winter. Thorough removal of infected branches before the growing season for two consecutive years often will stop or drastically slow development of new infections on reasonably vigorous trees. Cytospora cankers often are less severe on healthy trees. See "Maintaining Healthy Trees and Shrubs." While Cytospora cankers occur on all spruce species commonly planted in North Dakota, Colorado and Norway spruce are more susceptible than Black Hills spruce (and other white spruce varieties). Removal of seriously damaged trees may help any remaining spruce trees stay healthy. New spruce plantings should not be located near infected trees.

■ Diplodia tip blight

(Diplodia pinea) also called Sphaeropsis shoot blight and canker

Host(s): Pines, occasionally other conifers

Description/Biology: This fungus overwinters primarily in and on infected shoots, branches and cones as spores and mycelium. The fungus usually builds to high levels on cones before shoot blight becomes serious on infected trees. Fungal spores are dispersed during moist conditions. Current-year needles, shoots and cones are infected in late spring or early summer. The fungus develops rapidly in succulent needles and shoots, usually killing the entire shoot before needles or shoots are fully developed. The fungus also can infect larger branches, presumably through wounds or cracks, and cause branch death. ***Diplodia pinea*** is able to infect young plants and act as an endophyte, living perennially in the plant without causing disease. If conditions allow, the fungus apparently can become active suddenly and kill plant tissues. This may occur when the plant is stressed (e.g., drought) or wounded (e.g., hail). Such stress may kill plant tissues directly, followed by fungal fruiting on the dead branch, so determining if the stress or the fungus caused the initial damage may be difficult.

Damage/Symptoms: New shoots are killed, and often have short, brown, dead needles. Resin-soaking of shoots is common. This disease has killed branch tips, major limbs and entire trees in other areas. It usually is more severe on older cone-bearing trees but may severely affect young trees if they are near older infected trees. Continued infections deform and reduce growth. Infected cones develop normally.

Fungal fruiting bodies are seen easily on the scales of mature cones.

Comments: Fungicides that may be used as new growth begins include copper hydroxide + mancozeb, propaconizole, copper salts and thiophanate-methyl. This disease is becoming a concern in scattered pine plantings across North Dakota.

■ Disease: **Dutch elm disease (DED)**
(Ophiostoma ulmi and ***O. novo-ulmi)***

Host(s): Elm (all species adapted to North Dakota)

Description/Biology: The Dutch elm disease (DED) fungus overwinters in infected elm trees or recently cut elm logs. Beetles carrying the DED fungus may spread the disease. It also may be spread through movement of firewood or by root grafts. The native elm bark beetle and the European elm bark beetle (See "Native elm bark beetle" and "European elm bark beetle") act as vectors (carriers) of the DED fungus. Adult beetles lay eggs between the bark and wood of weakened elm trees or recently cut elm wood. If that wood was infected with the fungus, sticky masses of spores are produced in egg and larval feeding galleries. When adult beetles emerge from the infected elm log, they carry fungal spores on their bodies to healthy elms, where they feed. Through this feeding activity, the fungus is introduced into the water-conducting tissues of elm trees and spreads rapidly within the trees. As the tree responds to infection and the fungus continues to grow, water-conducting tissues become plugged and the tree wilts. The disease is spread over short distances when the beetles fly up to one-quarter mile in search of a feeding site and over long distances when the beetles are caught in wind that may move them many miles. Another way that DED is spread is through transporting infected elm for firewood. DED commonly is spread short distances from infected elms through root grafts, where the roots of neighboring elms grow together.

Damage/Symptoms: By plugging water-conducting tissues, DED results in wilting and dying of leaves outward from the infected area in branches or stems. Those leaves often are bright yellow early in the wilting stage and result in "flagging." A small flag in the top of a tree is where the initial infection occurred. [Cankers (see "Botryodiplodia canker) or other wilt diseases such as elm yellows and Verticillium wilt can cause similar symptoms.] As the fungus moves down the xylem, more and more of the tree is killed. Trees infected through root grafts suddenly wilt either on one side or throughout the entire tree. Trees may be killed in one season but usually die after several years. Peeling back the bark on affected limbs often reveals brown streaking in the sapwood. Confirmation of the disease requires laboratory testing. Extensive sanitation programs in larger communities have limited the impact of DED in those cities. However, smaller communities, conservation plantings and native woodlands continue to sustain heavy losses soon after the disease moves into those areas. DED will kill most American elms that are not in good, prolonged sanitation programs.

Comments: In landscape plantings and urban areas, sanitation is extremely important in managing the spread of DED. No economically feasible ways are available to reduce DED in natural stands. In an area where DED is present, elm wood never should be taken to an area with healthy elms unless all the bark is removed before transporting. All elm firewood should be burned or debarked prior to April 1, when beetles resume flight. A few elm logs secreted away negates a community's attempts at DED management. Dying trees should be cut down promptly and debarked, burned, buried or chipped and composted. Before removing an infected elm, trench between the diseased tree and nearby (within a distance equal to the height of the infected tree) healthy elms to a depth of at least 3 feet to reduce the chance of transmission through root grafts. Fungicide injections, by trained professionals, have been effective in reducing the probability that trees will become infected, but the injections are expensive, must be repeated every three years and do injure trees. Several fungicides and other products are labeled for
Dutch elm disease prevention, but only thiabendazole and propaconizole have been proven effective. If a tree becomes infected, quick removal is the most prudent and beneficial practice to save neighboring trees. DED usually kills only small to midsized branches of Siberian elm. Such infections can jeopardize sanitation programs because they usually are not detected. Several cultivars of American elm and Asian elm species and hybrids are resistant to DED and appear to be hardy in North Dakota.

■ Disease: **Elm black leaf spot**
(*Stegophora ulmea*)

Host(s): American elm

Description/Biology: This fungus overwinters in fallen leaves. New infections begin in the spring during moist periods when the temperature is approximately 45 to 75 F. Secondary infections (from spores produced in spots the first infections caused) can continue throughout the growing season if adequate moisture and appropriate temperatures are maintained. Young, rapidly growing leaves are more susceptible than older leaves.

Damage/Symptoms: Typically, yellow, but sometimes white, spots are distributed irregularly on the upper surface of leaves in early spring. About two weeks after the

spots appear, shiny coal-black pustules (acervuli) will be clumped around the center of the spots and may appear to be surrounded by a halo. Lower leaves usually are infected first, but the disease may spread upward if temperature and moisture are favorable for disease development. Even after heavy infections, severely blighted trees appear to recover during dry summers. This results from the growth of buds that typically would remain dormant until the following spring. Continual infection, year after year, can cause eventual decline of trees.

Comments: Elm black leaf spot rarely is life threatening to trees in established landscape plantings and forest populations. Although pruning, raking and burning infected plant parts decreases the level of infection in young isolated trees, it does little to decrease black spot damage in areas where spores can be blown in from nearby. Fungicide treatments, supplemented with optimum fertility, will help control black spot. Fungicides that may be used to manage elm black leaf spot include mancozeb, maneb and Bordeaux.

■ Disease: **Environmental leaf scorch**

(See also "Winter injury of evergreens" pg. 47)

Host(s): Elm, linden, maple, poplar, buckeye and others

Description/Biology: Some of the environmental conditions that may cause leaf scorch include poor soils (including highly saline soils), flood or drought, soil compaction, nearby excavation, root rot, high wind, severe temperatures, limited room for root growth and transplanting. Leaf scorch occurs when the roots of the tree cannot translocate enough water to the leaves to replace the water lost to transpiration. A lack of available water may cause this, but a flood also can result in the same symptoms when water is available to the roots but they are starved for oxygen and begin to die. Soil compaction also may cause death of segments of root mass, resulting in less water uptake. Excavation and limited space result in a reduction in, or lack of, root mass and less water uptake.

Damage/Symptoms: Injury symptoms include yellowing along the veins or margins that progresses to browning of leaves. Some leaves will become generally brown or show brown lesions on portions of the foliar tissue. The most diagnostic symptoms include marginal yellowing and browning. Minor late-season leaf scorch may be unavoidable on susceptible tree species in North Dakota. Defoliation may occur, and dieback from the branch tips may occur in severe situations.

Comments: The most effective way to manage this disorder is to provide adequate water to the plants. Do not plant into poorly drained soils, and try to ensure that sufficient space will be available for root mass expansion as the plants grow. If excavation, compaction of soil or physical disturbance to the roots occurs, little may be done to correct the situation. In this case, supplemental water, fertilizer and soil aeration may be warranted to help the plants recover. Disruption of the sapwood (e.g., by wounds, cankers, storm breakage) also can disrupt the flow of water to the leaves and result in leaf scorch. Some pathogens cause scorch in other areas of North America, but they have not been found in this region.

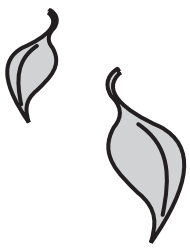
■ Disease: **Fire blight**
(*Erwinia amylovora*)

Host(s): Apple, cotoneaster, crabapple, mountain-ash, hawthorn and other Rosaceous plants

Description/Biology: Fire blight bacteria overwinter in cankered areas from previous years' infections. In the spring, as the temperature warms and the host and pathogen become more active, an ooze composed of plant sap and high numbers of bacterial cells exudes from the cankers. Additional infections occur when rain splash or insects transport this ooze to open blossoms, succulent leaves, vigorously growing shoots and wounds.

Damage/Symptoms: The classic symptom is dark brown or blackened leaves on a shoot with a "shepherd's crook" at the shoot tip. Holdover cankers, where the bacteria overwinter, will be found in branches and stems larger than a wood pencil in diameter and will appear darker in color than surrounding tissue. Sometimes these cankers will appear sunken. If the environmental conditions are right (warm, humid), infections may spread very rapidly and kill many shoots, branches, and rarely, whole trees. This is the most limiting problem of mountain-ash in this region.

Comments: Plant resistant cultivars and prune out cankers. Sterilizing pruning tools between cuts is essential to avoid spreading the bacterial pathogen to new cuts. Some sterilizing agents include one-fifth strength household bleach, Pine Sol® or denatured alcohol (not rubbing alcohol). Bleach and Pine Sol® are corrosive to metal, so rinse and oil pruners well when done. Avoid excess nitrogen fertilization and grass fertilizer to limit succulent terminal growth (most susceptible) to no more than 12 to 15 inches. Streptomycin (an antibiotic) or copper-based



fungicides may provide some early season protection from fire blight infections. Spray timing, labeled hosts and other requirements vary for different products; therefore, read product labels before purchasing them. An application after hail injury may offer some protection.

■ Disease: **Gray mold**
(*Botrytis cinerea*)

Host(s): Arborvitae, dogwood, hawthorn, juniper, lilac, pine, rose, viburnum and other woody and nonwoody plants

Description/Biology: This is a ubiquitous fungus that overwinters in plant debris or as sclerotia (hard masses of fungus) on plant debris. ***B. cinerea*** enters host plants through wounds, dead plant parts or possibly through direct penetration of intact surfaces. Many strains of the fungus produce dark resting bodies (sclerotia) in moist tissue. In the spring, sclerotia germinate to produce infective spores, which become airborne for dispersal. Moist, still air is most favorable for disease development. Lower leaves, shaded or dense plantings and plantings that remain wet for prolonged periods are at greatest risk.

Damage/Symptoms: The fungus infects and kills leaves, buds, flowers, twigs and new shoots primarily. Sparse webs of grayish-brown fungal growth are evidence of gray mold. ***B. cinerea*** may appear as tiny clusters of spores that may be seen with a hand lens. Symptoms usually develop after extended periods of high humidity or leaf wetness and rarely threaten the health of trees and shrubs in North Dakota.

Comments: It is important to facilitate good air circulation when trying to manage this disease. Avoid applying water to foliage and remove diseased or dying plant material.

■ Disease: **Iron chlorosis**
Host(s): Silver maple and occasionally other woody plant species

Description/Biology: Iron chlorosis is an abiotic disorder that is the result of a lack of iron in the plant. Too little iron in the soil may cause this deficiency, but in North Dakota, it usually is due to low availability of existing iron to the tree. The iron in the soil may exist in a form that is not available to the roots for absorption because of soil alkalinity, high water content or low temperature.

Damage/Symptoms: Affected trees have leaves that are pale yellow green to bright yellow. Leaves may be uniformly yellow, or more commonly the veins will remain green while the areas between veins turn yellow. Increasing severity of iron chlorosis causes symptoms from slightly yellow leaves with green veins, followed by entirely yellow leaves, then stunted yellow leaves and scorched yellow leaves (death of leaf margins); this is followed by defoliation and twig dieback, then branch dieback and eventual tree death. Silver maple generally is very susceptible to this nutrient disorder, but some individual silver maple trees do not have iron chlorosis.

Comments: Foliar applications of an iron chelate may provide temporary relief from the symptoms. Soil application and injections with iron chelate may help reduce severity of symptoms for a few years. If practical, adjustment of the soil pH may offer the best long-term solution to the problem. Micronutrient capsules implanted in the trunk are available as a longer lasting remedy than foliar applications, but this form of therapy injures the tree, and repeated injections may stress or ultimately kill the tree.

■ Disease: **Lirula needle blight**
(Lirula macrospora)

Host(s): Spruce (especially white spruce and the variety Black Hills spruce)

Description/Biology: This fungus overwinters in infected needles on the tree. From late spring through midsummer, it produces spores in infected needles that spread in splashing and dripping water. The current-season needles appear to be most susceptible. Fruiting bodies first appear on the lower surface of infected needles about two years after infection, and the fungus produces spores in those fruiting bodies three years after infection. Spores are released from late May through August, with peak releases during rain events from early June to mid-July.

Damage/Symptoms: Lirula needle blight is found most commonly in northeastern and north-central North Dakota, but has been seen in all areas of the state. The disease often will begin in the lower part of the tree. The first symptoms do not appear until 15 to 17 months after infection, when yellow bands appear. The bands gradually become a light purplish brown and expand over the entire needle before the next spring. By that time, a black band is present at the base of the needle. Large, smooth fruiting bodies develop along the length of the lower side of the then reddish-brown needles in late spring. Individual fruiting bodies may be as long and half as wide as the needle, and are easily visible. Additional black bands develop around some infected needles at the same time as fruiting body development. The color of infected needles slowly fades to tan by the next summer (three year after infection), which is when spores are released, and then to gray after spores are released. The gray needles with old fruiting bodies remain attached to branches for several years until they are weathered off. The damage caused is the presence of discolored needles (aes-

thetic damage) and the loss of functioning needles (growth loss). In severe cases, discoloration occurs in most of the crown and lower branches die.

Comments: In the past, most infections in landscapes appeared to originate on plants in nurseries, and spruce even one-fourth mile away from infected trees did not seem to be in danger. Conditions for dispersal seem to have been more favorable in recent years, and the connection with nurseries is not always found anymore. However, planting healthy stock and avoiding planting spruce at sites where Lirula already occurs are the best deterrents. Plantings should allow for air movement around the trees, even when they are mature. Accomplish this through initial wide spacing or removing some trees as they grow. Alternating spruce with other species can reduce the spread of the spores. Under average conditions, Lirula needle blight tends to be serious on few trees in a planting, so removal of the most heavily infected trees can reduce infection of other less susceptible trees. Two properly timed applications of fungicide in each of three consecutive years can control damage from Lirula. If Lirula needle blight does develop, chlorothalonil or Bordeaux mixture applied once in the spring as needles are 50 percent elongated (usually early June) and a second time one month later prevents most new infections that season. To break the three-year life cycle of the pathogen, the fungicide treatments must be repeated for three consecutive years. This disease is a greater problem on white spruce than on Colorado (blue) spruce.

■ Disease: **Marssonina leaf spot** (*Marssonina* spp.)

Host(s): Cottonwood, poplar

Description/Biology: These fungi overwinter on the previous season's shoot growth and fallen leaves. Spores produced in these tissues during wet weather in the spring infect leaves and new shoots. Spores are produced in the new infections and rain splashed onto adjacent leaves, causing more infections and sometimes building to epidemic levels by mid to late summer.

Damage/Symptoms: Spots on infected leaves appear as small circular to angular brownish lesions, often with a chlorotic halo. When spots enlarge and coalesce, they may appear as angular rust-brown to black blotches on leaves. Whitish fuzzy masses of spores may be evident on some of the larger spots. Petiole lesions usually are lens shaped with white centers and black borders. Severe infections cause defoliation, but the disease usually is not severe in North Dakota. Repeated defoliation can predispose trees to other problems.

Comments: Plant resistant varieties when possible. For existing plants, remove dead and infected twigs from trees. Rake up and destroy fallen leaves during the growing season. High-value ornamental plantings may require application of a fungicide such as chlorothalonil.

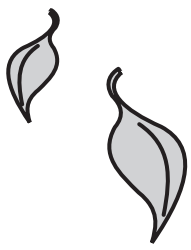
■ Disease: **Melampsora leaf rust** (*Melampsora medusae*)

Host(s): Aspen, cottonwood, larch, poplar

Description/Biology: Two different host species are required to complete this fungal pathogen's life cycle, but a repeating stage may allow year-to-year infections without completing the full life cycle. This fungus overwinters on fallen aspen, cottonwood or poplar leaves, from which it produces spores in the spring that can infect a conifer host and possibly another spore type that infects a broadleaf host. On the conifer host, the fungus produces spores that infect aspen, cottonwood or poplar leaves. Early-season and midseason spores produced on these hosts can re-infect the broadleaf hosts. Some spores produced after midsummer will overwinter in lesions on fallen leaves.

Damage/Symptoms: Yellow to orange pustules appear in midsummer on broadleaf foliage. Later in the season, an orange to brown waxy layer covers these pustules and contains the overwintering stage of the fungus. Severe infections can cause early defoliation of broadleaf hosts. Repeated defoliation can predispose trees to other problems.

Comments: Larches are not prevalent in North Dakota, so new infections mostly are caused by windblown spores coming in from adjacent areas. If a problem develops with rust, early defoliation may weaken young or newly planted trees. Protectant fungicides, such as triadimefon, help prevent infection. Avoiding monocultures of susceptible cultivars substantially reduces damage. Some hybrid poplar cultivars (e.g., Norway, Robusta and Imperial) are resistant.



■ Disease: **Oak anthracnose**
(Apiognomonia quercina)

Host(s): Bur and other oaks

Description/Biology: This fungus overwinters in shoots, buds and fallen infected leaves. Under cool, wet conditions in the spring, fruiting bodies on diseased tissue release spores that infect succulent new growth. Infections may occur on expanding leaves, shoots or buds. When terminal twigs and buds are killed, new shoots may develop from farther down the twig, thus creating a cluster (or broom) of shoots. Spores that form in early infected tissues can infect later-flushing shoots and leaves, if weather conditions allow. However, development of this disease usually subsides by late spring.

Damage/Symptoms: Symptoms can vary, depending on weather conditions and the stage of leaf development. Generally three patterns of symptoms appear: twig blight, shoot blight and leaf blight. Twig blight appears as twigs killed prior to bud break. The tree may produce numerous shoots interior to these dead twigs and buds. Shoot blight occurs as new expanding shoots are infected and killed quickly, yielding a scorched appearance. Leaf blight produces necrotic lesions on any portion of the leaf, but often are bounded by the veins and midrib. Distortions may occur around the necrotic lesions and are due to continued growth of uninfected leaf tissue while infected tissues cease growth. Infected tissues rapidly discolor to various shades of green, gray, brown or black. The older, central areas of these lesions may appear lighter in color, compared with outer portions of the dead tissue. Healthy, vigorous oaks generally are tolerant of the damage that this disease imposes. Young trees, trees that have been defoliated for several consecutive years, or recently transplanted trees may become stressed and predisposed to other damaging agents. Established oaks on good sites can withstand substantial defoliation over a few years before their health declines substantially. Aesthetics of a tree can be damaged during any season that infection occurs.

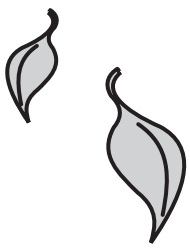
Comments: Raking and destroying fallen leaves may reduce infections in subsequent years. Fertilizing, watering and mulching to promote growth may encourage refoliation, but also may result in more succulent growth that is susceptible to infection. See the note about fertilization on Page 5. Chemical control may be warranted for trees that have experienced severe infections for consecutive years or trees in which aesthetics are important. Planting, thinning and pruning practices that result in more air movement and longer distances between susceptible tissues favor reduced disease development. Avoid planting oak seedlings in the understory of older oaks because of this disease. Protectant fungicides must be used at properly timed intervals to prevent anthracnose infection. Certain formulations of thiophanate-methyl are labeled for treatment of anthracnose. Chlorothalonil may be applied to trees only in the red oak group (northern pin oak, northern red oak); it is not registered for the white oak group (bur oak, white oak).

■ Disease: **Oak leaf blister**
(Taphrina caerulescens)

Host(s): Bur and other oaks

Description/Biology: Fungal spores infect new leaves as buds begin to open in the spring. Following infection, the fungus grows intercellularly within the leaf tissue, causing leaf deformities termed blisters to form. Under favorable conditions, these blisters may continue to expand as the fungus invades new leaf tissue. New leaves formed in midsummer also may be infected, causing a second cycle of this disease. The spore-bearing structures of this fungus are produced on the lower surface of blisters and can be seen only with a microscope. The fungus overwinters on bud scales and in bark crevices.

Damage/Symptoms: This disease often goes unnoticed except during occasional moist years or in localities that favor heavy infections. Leaf blisters appear as wrinkled, distinctly raised bulges on the upper leaf surface and are lighter in color, compared with noninfected portions of the leaf. The tissue on the upper surface of the blister may stay green for several weeks before desiccating and turning brown, while the lower leaf surface may appear gray. Typically, blisters are 3 to 20 mm across but may coalesce and encompass the entire leaf. Often, severely blistered leaves may curl and fall from the tree prematurely. These disease symptoms are more prominent in the lower, more shaded portions of the crown. Bur oak is a hardy, resilient species and this particular foliar disease rarely causes substantial physical damage. Despite this, oak leaf blister can cause stress to young trees, trees that have been severely infected for several consecutive years or newly transplanted trees. It can cause aesthetic damage, but this is infrequent except where the tree's genotype and local environmental conditions are particularly favorable for



the disease.

Comments: Cultural practices such as proper watering and mulching may increase the tree's vigor and may sufficiently minimize the damage that this pathogen causes. High-value ornamental trees may benefit from chemical control in areas of high disease pressure. Protectant fungicides must be applied prior to and during bud break to prevent infection. Fungicides are not effective once leaves begin to expand because infection already has occurred. Various formulations of chlorothalonil and mancozeb are registered for this disease. Some authors also recommend either lime sulfur at a rate of 10 tablespoons per gallon or Bordeaux mix. Removal of infected leaves has not been shown to reduce disease development effectively.

■ Disease: **Plum pockets/leaf curl** (*Taphrina* spp.)

Host(s): Plum, other ***Prunus*** sp.

Description/Biology: These fungi apparently overwinter as spores in buds and distorted plant parts and infect young shoots, leaves or flower parts as buds break and growth begins. During the summer, the fungus continues to grow in infected fruit, leaves and shoots. It produces fungal spores later in the season, but no further infections occur until the following spring.

Damage/Symptoms: Growth of the ***Taphrina*** spp. in the plant causes distorted growth, overgrowth and pigment production in the host. This may result in symptoms such as leaf curl and witches'-brooms on some trees. Infected fruit often is hollow, distorted and enlarged, forming structures called "pockets" up to 10 times normal size. These pockets may range in color from greenish yellow to bright red and lack developed seeds. Infected shoots and leaves are thickened and deformed (curled). Later in the season, infected tissues are dark gray or black. Serious fruit loss and plant deformity can result if infection is not managed.

Comments: Managing this disease during the summer and fall is not effective. The best management practice is to prevent infection in the spring. Infected plant parts on the ground and in the tree should be removed from the area. Lime sulfur or Bordeaux mixture can be applied when the temperatures are above freezing but before buds begin to swell.

■ Disease: **Powdery mildew** (several species of *Erysiphe, Microsphaera, Phyllactinia, Podosphaera, Sphaerotheca,* and *Uncinula*)

Host(s): Crabapple, currant, hawthorn, honeysuckle, lilac, oak, plum, poplar, rose, willow

Description/Biology: These fungi overwinter in infected leaves that fall to the ground. Spores from these leaves infect current-season leaves. The fungi grow inside the leaves, as well as superficially on the leaf surface, producing asexual spores throughout the season. These spores cause new infections through the growing season. As the plant's dormant season approaches, the fungi produce sexual fruiting structures on the leaf surface that are at first round and colorless, then become yellow, brown and finally black. Spores that continue the disease cycle are produced from these structures in the spring.

Damage/Symptoms: Damage from powdery mildew most often is an aesthetic concern. Lesions are not formed in infected leaves, as occurs with most foliage diseases. Rather, a white to dirty white powdery mat develops on the leaf and fruit surface. Premature defoliation can occur.

Comments: Fungicides are seldom necessary, but those registered for use on powdery mildew include sulfur, thiophanate-methyl, triforine and chlorothalonil. Avoid planting in the shade, watering the foliage and excessive fertility. Properly space and prune plants to promote good air circulation.

■ Red band (Dothistroma needle blight) *(Dothistroma septospora)*

Host(s): Pines

Description: Dothistroma needle blight (sometimes called red band disease) of pines has not been found in North Dakota. The disease commonly is called red band disease, but that name properly is applied only in the Pacific Northwest region because that is the only place where the band is red. It is mentioned here because many people see banding around pine needles in North Dakota, search and find a description of red band disease, and misdiagnose their sample. Banding around pine needles in North Dakota has several possible causes. To diagnose Dothistroma needle blight, fruiting bodies of the fungus must be present in the bands. If dead bands on pine needles contain fruiting bodies, chances increase that the disease is Dothistroma needle blight. To complete the diagnosis, check the spores that are in the fruiting bodies. Spores of ***Dothistroma pini*** are elongate with septations across the spore. The precise spore characters must be determined for accurate diagnosis. Because the disease has not been found in North Dakota, get a confirming diagnosis from a plant pathologist at NDSU or elsewhere.

Bands around needles are of two types. The death of at least the outer cells cause brown or yellow discoloration in spots or bands around green portions of needles. Such bands and spots occur if something kills some or all of the mesophyll

tissue in a portion of the needle. Resin causes the dark bands around brown or yellow portions of needles. Resin canals run lengthwise in the needles and if they are disrupted, resin runs into the surrounding tissues in that part of the needle, causing a dark green spot on the needle or band around the needle. The resin-covered cells stop photosynthesizing and the area gradually turns brown.
The needle may or may not die above that point, most likely depending on whether the vascular bundle in that part of the needle was damaged. In North Dakota, feeding by aphids or other sucking-piercing insects, Cyclaneusma needle blight, and environmental damage such as freezing and air pollution seem to be the most common causes of bands or spots.

■ Disease: **Rhizosphaera needlecast**
(*Rhizosphaera kalkhoffii*)

Host(s): Spruce (especially Colorado spruce)

Description/Biology: This fungus overwinters in infected needles on the tree and in fallen needles. In the spring, it produces spores in infected needles and splashing and dripping water spreads the spores. The newly emerged needles are most susceptible. Fruiting bodies develop in as little as several months or as much as several years after infection.

Damage/Symptoms: Rhizosphaera needlecast historically has been a greater problem in northern and eastern North Dakota than western areas of the state. The disease often will begin in the lower part of the tree, killing interior needles as it progresses up the tree. Needles first will turn yellow (for a few days) and later purplish brown. Infected needles may turn brown within six to eight months after infection or remain green for several years. The infected needles may fall before browning or remain attached for several months after browning. The fruiting bodies of ***R. kalkhoffii*** will emerge through the normally white stomatal openings of brown or green needles, causing the stomatal openings to appear black under 10X magnification. In severe cases, only current-season needles remain green, and prolonged defoliation results in dead branches in the lower crown.

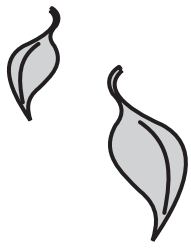
Comments: Prevention of Rhizosphaera needlecast begins with planting healthy stock and allowing adequate space for mature trees to develop. This can be difficult in windbreaks, where density is important for wind management. When Rhizosphaera needlecast does develop in established trees, chlorothalonil or Bordeaux mixture applied once in the spring as needles are 50 percent elongated and a second time one month later, shortly after needles are fully elongated, usually controls early infections. Two consecutive years of fungicide treatments are necessary for adequate control. This disease is a greater problem on Colorado spruce than white spruce and its variety Black Hills spruce.

■ Disease: **Septoria leaf spot and canker of poplars**
(*Septoria musiva*)

Host(s): Cottonwood, poplar

Description/Biology: This fungus overwinters in fallen leaves, and cankered twigs and stems. During periods of wet weather in the spring, it releases spores, which are windblown or rain-splashed onto new leaves, twigs and stems. Secondary infections occur throughout the growing season as it produces more fungal spores in infected tissues. The fungus usually infects only the leaves at first, but after substantial defoliation for several years, the tree seems to become susceptible to both leaf and stem infection.

Damage/Symptoms: Leaf spots first may develop by early summer. The photosynthetic area of leaves decreases with severe infection, and tree growth is reduced. Premature defoliation (as early as July) is common on highly susceptible trees and may predispose trees to cankers and other problems. This may be the reason that Septoria cankers begin forming after a few years of foliar infection. Leaf spots commonly are small and angular, sometimes coalescing to form large spots, but also may be circular and up to ½ inch in diameter with brown or yellow margins, large and irregular-shaped with dark margins and tan centers, or very small and white or silvery. Cankers first are detectable by mid to late summer, but are easiest to see after leaf drop. They appear as a thin vertical line 1 to 2 inches long from which sap slowly runs down. Within a few months, the sap no longer runs down from the slit and the host begins forming enough callus tissue around the canker that the bark is raised in a vertical ellipse around the area that had been split. The canker does not expand beyond the callus in



future years, indicating that it survives for only one season (annual canker). Many cankers may be present, which results in partial or full girdling of the stem.

Comments: Plant uninfected stock, remove highly susceptible varieties if they are damaged or threaten other varieties, and replant using resistant clones. Northwest poplar is highly susceptible to Septoria leaf spot and canker, but is able to maintain its vigor in spite of defoliation and cankers. Norway, Robusta and Imperial poplars are quite resistant to this disease. Maintain plant vigor. Leaf litter cleanup in the fall may be helpful if the tree is in a landscape setting. Fungicides labeled for use on this disease include chlorothalonil and mancozeb.

■ Disease: **Sooty mold**
(many fungi)

Host(s): Many tree species, common on boxelder, elm, linden, maple and pine

Description/Biology: These fungi are not plant parasites but opportunistic organisms that grow on the sweet honeydew that sap-sucking insects (especially aphids) excreted. The fungi produce spores on the leaf surface. Some of these spores colonize other leaf surfaces during the same season and others overwinter.

Damage/Symptoms: Sooty mold fungi appear as a black powdery or "sooty" growth on leaves, stems or branches of many trees. While unsightly, this condition rarely has a negative impact on the tree. Sooty mold can indicate an aphid (or other sap-sucking insect) problem that may warrant control measures. It is most common in shaded, high-humidity areas.

Comments: If the trees are young and the sooty mold appears to be covering much of the leaf surface, hosing off the leaves and branches periodically throughout the growing season often eliminates the honeydew on which the fungi grow. Control the underlying insect problem if necessary. Increased light or air circulation and reduced moisture will reduce sooty mold development. These fungi rarely are a concern for tree health but can cause aesthetic damage.

■ Disease: **Tubercularia canker**
(Tubercularia ulmea)

Host(s): Honeylocust, Russian-olive, Siberian elm and many other species

Description/Biology: This fungus overwinters in cankers on branches and stems. Spores are dispersed in rain splash, by adhering to birds or insects or on horticultural implements. The fungus infects trees through wounds in the bark that factors such as adverse weather conditions, insect feeding and frost injury caused. It also may enter through human-induced damage that pruning, weed control and harvest implements cause. Cankers may expand over several years, or the host may stop their progression at any time.

Damage/Symptoms: As infected tissues die, the infected area becomes discolored and sunken. Gummosis (exudation of sticky plant fluids into globs on the bark surface) may occur below the cankered area, especially on Russian-olive. If the fungus encircles (girdles) the stem during the growing season as it grows through the outer sapwood, cambium and bark, the leaves on the dead branch turn brown and remain attached, resulting in a flag. Light-colored asexual fungal bodies develop on the infected tissues and usually turn black within two weeks. Brick red sexual fruiting bodies occasionally develop around the black asexual fruiting bodies. Tubercularia canker can deform or kill stressed trees and shrubs as it kills branches and stems.

Comments: This disease is very common in North Dakota and heavy losses have been seen in North Dakota highway, urban and conservation plantings. See "Maintaining Healthy Trees and Shrubs."

■ Disease: **Valsa canker**
(*Valsa* spp. and *Leucostoma* spp.)

Host(s): ***Prunus*** spp., such as plums, chokecherry, apricot and cherry

Description/Biology: These fungi overwinter in cankers on branches and stems. Existing cankers may expand, and they produce spores that cause new infections when temperature and moisture is favorable, wounds are present and host resistance is impaired. Windblown rain and dripping water spread the spores. Cankers may survive and produce spores for one to many years.

Damage/Symptoms: Sunken cankers form, and fungal spores develop in small black fruiting bodies in the bark. In some cases, the fruiting bodies appear to be covered with a white to tan powdery-looking substance. If moisture is adequate, these spores may be exuded in tan- to orange-colored tendrils from mature fruiting bodies. Limited cankers on large stems are oval, and the canker margin generally enlarges gradually each year to form a target canker that may be sunken or swollen. Branch cankers may be very long. In the case of Valsa canker, clear to opaque gums are exuded from the host below the canker, especially on cherry and chokecherry. The exudates may become black and hard or crusty as they dry.

Comments: These fungi typically colonize weak, wounded or less vigorous hosts, but Valsa canker can develop on apparently vigorous trees. See "Maintaining Healthy Trees and Shrubs." Winter injury, pruning wounds, mechanical damage, insect injury and leaf scars are all sites where infection may occur. Management strategies include pruning in the early spring to facilitate healing and prevention of lawn mower-caused damage. Remove and destroy cankered branches to reduce local sources for further infection. Do not plant new trees of susceptible species next to older, diseased trees.

■ Disease: **Venturia leaf and shoot blight** (*Venturia* sp.)

Host(s): Poplar, willow

Description/Biology: These fungi overwinter on shoots killed in the previous season and on infected leaves that fall to the ground. Spores infect young, succulent tissue in the spring. As leaves and shoots become more hardened later in the season, they become resistant to infection.

Damage/Symptoms: Infection begins as small brownish spots that expand to form brown to black leaf and shoot spots. Young shoots and leaves shrivel and turn black. The disease may cause disfigurement. It seldom is a serious threat to established trees unless it occurs during several successive years. Young trees or nursery trees may be damaged to a greater extent.

Comments: Management of the disease in established trees requires pruning affected shoots and removing leaves in the fall. Fungicides containing fixed copper may provide protection for young trees. Published documentation of this disease has not been made for North Dakota. Anything that cuts off the water supply from growing shoot tips also can cause the symptoms described for this disease; the succulent leaves and shoots simply wilt and turn black. Unless fruiting bodies of the pathogen are found, Venturia most likely is not the cause of such symptoms in North Dakota.

■ Disease: **Verticillium wilt** (*Verticillium dahliae*)

Host(s): Many tree species, but especially catalpa, elm, maple and stone fruits

Description/Biology: This soil-borne fungus overwinters in hardened resting structures in the soil or host tissue. The fungus invades root tissue or enters through wounds, such as those that contaminated pruning tools created. It grows in xylem, the water conducting tissue, and causes foliage to wilt. V. dahliae may remain viable in trees for several years after infected trees have died.

Damage/Symptoms: Acute and chronic symptoms are associated with this wilt disease. In some species, such as maples, the disease is characterized by the sudden death of one or more scattered branches after they have fully leafed out. Acute symptoms include wilting, abnormal red and yellow color of leaves, dry and curling leaves that may cling to the branch (flagging), and defoliation. Chronic symptoms include slow growth, sparse foliage, stunted leaves and twigs, leaf scorch and heavy seed crops. Both chronic and acute symptoms can appear at the same time. In the sapwood of most species, the fungus may cause green (in maple), dark brown or black streaks. Some species, such as green ash, do not develop streaking. When severe, this disease can kill branches or entire trees.

Comments: No control is available for Verticillium wilt. A tree may recover if it's appropriately watered and fertilized to promote good health. Prune out affected branches. Do not plant another susceptible tree where Verticillium wilt is suspected since the pathogen most likely remains in the soil. Tree species reported to be resistant to this wilt disease include birch, flowering crabapple, hawthorn, honeylocust, mountain-ash, pine, spruce and willow.

■ Disease: **Western gall rust** (*Endocronartium harknessii*)

Host(s): Some hard pines (e.g., ponderosa and Scotch)

Description/Biology: This fungus overwinters in infected pine stems and branches. Aeciospores infect succulent needles and shoots (and rarely through wounds) in late May and early June. The fungus becomes perennial in wood near the infection site, eventually causing a gall. Aeciospores first are produced on galls two years after the initial infection and every year thereafter as long as the galls or branches survive. These spores are windblown to new shoots and cause infections if free moisture is available long enough and the host is susceptible.
Western gall rust does not require an alternate host, as do many rust fungi.

Damage/Symptoms: Small red to purple discolored areas develop within a few weeks on needles or shoots around the infections, and the shoot sometimes splits in that area within a few months. The shoot begins swelling late in the season of infection or early the next season. Distinct galls develop by fall of the second season. The galls vary from spindle-shaped to round. In the spring of the third season (two years after infection), and in subsequent years, spores begin forming under the surface of the galls. When the

spores have matured, the surface of the gall peels away or cracks, and bright yellow-orange powdery spores appear on the surface of the galls. The galls increase in size each year and may live for decades. Branches may die above galls or witches'-brooms may form around galls, both of which deform trees if severe. Trees may break at the point of stem infections. This disease can be very damaging in nurseries and can cause dieback and stunting in landscape and Christmas trees.

Comments: Managing the disease on established trees requires removal of galls from infected trees. For high-value stock in nurseries or plantations, fungicides such as mancozeb and maneb are labeled for this disease. Fungicides should be applied before infections begin in the spring or early summer and repeated after heavy rains and at two-week intervals as long as necessary. Do not plant young, susceptible pine species within about 500 yards of infected trees.

■ Disease: **Wetwood,**
also called slime flux (bacterial species are often, but not always, associated with this disorder)

Host(s): Cottonwood, elm and occasional other species

Description/Biology: The bacteria that normally are associated with wetwood overwinter in the soil or host tissue. They are common water and soil inhabitants. These bacteria can infect trees through root wounds and bark beetles or on pruning tools also may transmit them from tree to tree. Once present, the bacteria reside without oxygen indefinitely in older xylem tissue of trees. Their presence results in a buildup of pressurized liquids in the wood.

Damage/Symptoms: The most typical symptom is light gray (when dry) or dark brown or black (when wet) streaking on the trunk, caused by exudation or leaking-out (bleeding) of the pressurized liquids out of and down from openings, often in branch crotches or stubs. Once the liquid is on the surface, other organisms grow on the liquid and ferment, resulting in a yellowish, sometimes smelly material called slimeflux. The infected wood is dark stained and somewhat weakened. The damage mostly is aesthetic as a result of the bark staining and odor, and many people never notice it. If the wood is used for lumber, its value is reduced. The slimeflux may be quite acidic and eventually kill the bark that it flows over.

Comments: No treatment is available for this disorder. Sterilize tools after pruning an infected tree to reduce the possibility of spreading the disease on pruning implements. Avoid stressing or wounding trees to reduce expansion of the wetwood area within trees. Forcing the liquid to flow out a tube or pipe so it does not contact the bark sometimes reduces bark damage. Because the liquid may be under pressure, wear eye protection if attempting the drainage.

■ Disease: **Winter injury of evergreens**
(See also "Environmental leaf scorch" pg. 38)

Host(s): Arborvitae, juniper, pine, spruce

Description/Biology: Reddish-brown dead foliage first seen on evergreen trees in the spring often is the result of injury sustained the previous winter. This injury may be the result of desiccation (drying of the foliage) or an early fall freeze. Desiccation occurs when the ground contains inadequate moisture due to drought, frozen ground or whenever else a plant is unable to access moisture in the soil. Trees then are unable to take up enough moisture to replace water that the foliage lost. Early fall or late spring freezes (especially rapid drops in temperature to below freezing) can kill evergreen foliage when it is not adequately hardened off. If the damage is severe, some or all of the buds also may die.

Damage/Symptoms: Since wind can accelerate water loss from foliage, desiccation often is directional toward prevailing wind. Winter desiccation may be greater near light-colored surfaces (white siding, white rock mulch, etc.) on the side of the tree toward the sun, or when trees are planted improperly, stressed by insects/diseases/other environmental factors, fertilized at an improper time or have poor winter hardiness. Winter desiccation and early fall freezes most often kill only foliage, while buds and branches usually are unaffected. Foliage that both early fall freezes and winter desiccation killed often remains green as long as temperatures are cold. Damaged needles then turn brown when temperatures rise. Snow insulates needles, so damage may occur only above the snow line. If the buds were not killed, new foliage emerges the following spring or early summer. Assessment of total injury should be made only after new growth has occurred. Winter injury often is an aesthetic problem in evergreens but does kill trees occasionally.

Comments: Only plant trees from a hardy source. To reduce the incidence and severity of winter desiccation, water trees adequately during midsummer drought and late in the fall. However, avoid providing supplemental water in

late summer, approximately mid-August to mid-September (except during severe drought), so buds will set and shoots begin hardening. Application of anti-dessicants or covering plants during the winter may help avoid injury, but plants that need this level of protection probably are not adequately hardy for the site.

■ Disease: **X-disease**
(X-disease phytoplasma – a type of bacterium)

Host(s): Chokecherry, some other stone fruits, some herbaceous plants

Description/Biology: X-disease phytoplasmas overwinter primarily in the roots of infected host plants. Leafhoppers move them from tree to tree. They live in the phloem (food-conducting tissues of host plants) and cause a decline of susceptible hosts.

Damage/Symptoms: New growth on infected trees may begin later in the spring than on healthy trees. The characteristic symptom is the presence of bright orange to red leaves before the time of fall coloration. A second flush of growth may occur in late summer. In subsequent years, leaves and shoots may be progressively smaller. Development of rosettes or tufts of leaves on the ends of branches is common. Fruit on infected chokecherry may be pointed and red in color. In susceptible plants, growth slows progressively over three to four years, followed by progressively severe branch dieback. This disease has damaged and killed many chokecherry plants in North Dakota.

Comments: The only management tool available is planting disease-free stock and isolating plantings. Removal of all infected trees within a radius of 500 feet has been shown to reduce disease spread in other regions. Interplanting of chokecherry with other trees and shrubs may reduce the spread of the disease and reduces the aesthetic impact if plants are lost. X-disease resistant plants are being developed for release in the future. Wild plums ***(Prunus americana)*** may be symptomless hosts.

Modified from: **"Pesticide Safety: A Guide for Gardeners and Homeowners"**
NCR 590, June 1996

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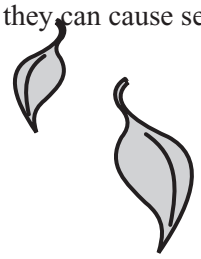
Pesticides can be very effective tools in managing pest problems. If used improperly, they can cause serious damage to people, pets and the environment. Always use proper protective clothing and follow pesticide label instructions.



Read and Follow the Label Directions

As a pesticide applicator, you are legally responsible for reading, understanding and following the label directions. Pesticide labels usually will contain the following sections:

- **Product name:** Indicates type of pesticide or what types of pests it will control.
- **Ingredient statement:** Lists the amount of each active ingredient and the total amount of inert ingredients.
- **Signal word:** Indicates the toxicity of the product.
- Products labeled "DANGER POISON" and accompanied by a skull and crossbones symbol are highly toxic. Products labeled "DANGER" without the word "POISON" or the skull and crossbones symbol can cause severe skin injury or irreversible eye damage.
- Products labeled "WARNING" are moderately toxic or may cause moderate eye or skin irritation.
- Products labeled "CAUTION" are slightly toxic or may cause slight eye or skin irritation.

Pesticide Safety

- Warning about potential hazards to humans, domestic animals and the environment. They also indicate special fire, explosion or chemical hazards and methods to avoid or minimize risks.
- **Statement of practical treatment/ first aid information:** Indicates antidote or first aid treatment to administer.
- **KEEP OUT OF REACH OF CHILDREN:** Pesticides always must be stored and kept out of reach of children.
- **Directions for use:** Warns that federal law requires the pesticide to be used according to label directions. Indicates location, amount, frequency, and method and timing of the application. The label also indicates when re-entering the treated area is safe. ***Do not exceed recommended limits.***
- Other information on the label includes the **name and address of the manufacturer, EPA registration and establishment numbers, and storage and disposal information**.

Special Precautions when Using Pesticides

- Examine the area to be treated and the surrounding area. Are plants or animals present that the pesticide could harm? Don't spray if you cannot guarantee they will not be injured. You are responsible for any damage that could occur.
- Wear all protective clothing and equipment listed on the label, such as long-sleeved shirts, coveralls, chemical-resistant gloves, goggles, etc.
- Use pesticides only on plants designated on the label.
- Calibrate the sprayer or applicator to apply the correct amount. Appling more pesticide than the label states is illegal and unsafe.
- Use all chemicals in well-ventilated areas to avoid inhaling fumes. Work outdoors if possible. Use protective gloves and/or masks when label instructions recommend them.
- Be especially careful while working with the concentrated pesticide during mixing.
- Don't spray on a windy day, when the spray could drift on you or into a neighbor's yard.
- Do not eat, drink or smoke when using pesticides because traces of the chemicals may be transferred from hand to mouth.
- Wash hands thoroughly with soap and water after handling pesticides and before eating.
- Avoid wearing soft contact lenses when dealing with pesticides. Soft contact lenses may absorb vapors from the air and hold them against your eyes.
- Always avoid unnecessary exposure to pesticides. Be especially careful to keep children, pregnant women, sensitive individuals and pets away from areas where pesticides are being or have just been applied.
- An alternative is to hire a professional pesticide applicator. Be sure the applicator is certified and has good references.

Disposal of Pesticides

- Never put potentially hazardous waste, such as pesticides, directly in the garbage.
- Share remaining pesticides with someone who can use them as intended.
- Don't pour remaining chemicals down the drain.
- Triple rinse empty glass, plastic and metal pesticide containers by filling the containers one-quarter full of water, covering tightly and shak-

ing. Apply the rinse water on the original targeted area. Wrap the container in newspaper and send to the landfill or dispose of as directed on the label.

- Do not reuse empty pesticide containers.
- Wrap aerosol containers in several layers of paper and place in a covered trash container.

Storage

- Store pesticides out of reach of children — in locked cabinets or in cabinets with childproof latches.
- Store pesticides only in their original containers with labels visible and intact.
- Mark the date on containers that are put into storage with a permanent marker and keep an up-to-date list of products and purchase dates near the storage area. Use oldest products first.
- Keep metal containers dry to prevent corrosion and possible leakage.
- Seal containers tightly after using.
- Store all pesticides away from food, feed, seed, fertilizer or water.

Dealing with Spills

- Don't leave the spill unattended. Send someone else for help.
- Keep people, especially children, and pets upwind and away from the spill.
- Protect yourself by wearing AT LEAST the protective clothing and equipment listed on the pesticide label.
- If indoors, ventilate the area with fans and open windows and doors.
- Try to confine the area of the spill. Use a nonflammable absorbent material, such as cat litter, to soak up the spill.
- Place the material in a noncorroding container, such as a plastic bucket with a tight-fitting lid.
- Seal the container and label it with product name, amount and absorbent material used.
  In some communities, the product will need to be safely stored until the community holds a household hazardous waste collection.
- Rinse the area several times with water and rags. Wash the area to remove traces of the product. Don't use household equipment to clean the spills, as this equipment will need to be discarded to avoid contamination of your household.

Safety Clothing and Equipment

Check the label under "Hazards to Humans and Domestic Animals" to see what special protection you need when applying a pesticide. Protective clothing may include a hat, goggles, mask, rubber gloves, rubber boots and/or a long-sleeved shirt and long pants. A respirator approved for pesticides may be needed for some pesticides that pose a risk from inhalation.

Clothing Cleanup

- Prerinse contaminated clothing.
- Keep clothing used during pesticide application separate from family laundry. Launder clothing using hot water and a heavy-duty detergent after each use.
- Clean washing machine after use by running it through a normal wash cycle without clothing.
- Line-dry clothing (see Extension publication HE-382, "Guidelines for Safely Laundering Pesticide-Contaminated Clothing," for further information).

Application Equipment and Cleanup

- The pesticide sprayer or applicator needs to be in good operating condition and properly calibrated to apply the correct amount of pesticide.
- Clean all equipment, including mixing tools, after each use. Triple rinse with clean water and allow to dry.
- If you used a sprayer, rinse it with a small amount of water and spray over an area that may be treated legally. Clean the sprayer with water or as directed on the label. Rinse well and spray on an area that can be treated legally.

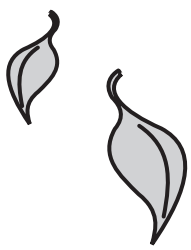
- For information on calibration of pesticide sprayers or applicators, contact your county office of the NDSU Extension Service or your pesticide supplier.

First Aid

Always read the first aid information on the label before applying the pesticide to know what to do in case of accidental contact with the skin or eyes. When seeking medical help, always bring the pesticide label.

- **Skin exposure:** Drench the skin and clothing with water, then remove all contaminated clothing and wash skin thoroughly with soap and water. Wash hair and fingernails thoroughly, also.
- **Eye contact:** Rinse eyes immediately with a stream of clean water and continue rinsing for 15 minutes. Victim should blink as much as possible.
- **Inhalation:** Get to fresh air immediately. Begin artificial respiration if the victim isn't breathing. Seek medical help.
- Ingestion: Check the product label to see if it recommends inducing vomiting. Sometimes vomiting is dangerous. Seek medical help.

For more information about safe pesticide use, contact your county Extension office.



Disease Control Products

Chemical name	Product names
aluminum-tris	Aliette, Prodigy
captan	Captan, Captec
chlorothalonil	Daconil, Manicure, Ortho Multipurpose Fungicide, Thalonil, Twosome Flowable
copper hydroxide	Kocide
copper hydroxide + mancozeb	Junction
copper salts	Camelot
copper sulfate	Bordeaux mix
etridiazole	Terrazole
fenarimol	Rubigan
iprodione	Chipco
mancozeb	Dithane, Flowable Mancozeb, Fore, Mancozeb
maneb	Pentathalon
mefenoxam	Subdue
myclobutanil	Eagle, Golden Eagle, Systhane
pentachloronitrobenzene (PCNB)	Engage, Revere, Terrachlor
propaconizole	Alamo, Banner Maxx
streptomycin	Agri-strep, Agri-Mycin 17
sulfur	
lime-sulfur	Lime-sulfur, Orthorix
wettable sulfur	Kolospray, Microsulfur, Sulfur
thiabendazole	Arbotect
thiophanate-methyl	Cleary's 3336
triadimefon	Bayleton, Accost, Strike
triflumizole	Terraguard
triforine	Orthonex
vinclozolin	Curalan, Touche

Insect/Mite Control Products

Products recommended for the management of insect and mite pests of trees and shrubs.

Always Read and Follow **the Label!**

Synthetic Insecticides	aphids	plant bugs	leafhoppers	scale insects	spider mites	gall insects	leaf beetles	caterpillars	sawflies	wood borers
acephate (Orthene® and Isotox®)	●	●	●	●	●		●	●	●	
carbaryl (Sevin®)	●	●	●	●		●	●	●	●	
cyfluthrin (Bayer Advanced™ Garden® PowerForce®)	●	●	●				●	●	●	
dicofol (Kelthane®)					●	●				
dimethoate (Cygon®)	●									
esfenvalerate (Bug-B-Gone®)	●	●	●				●	●	●	
horticultural oils				●	●	●				
imidacloprid (Bayer Advanced™ Garden® Tree and Shrub)	●	●	●	●			●		●	●
malathion	●	●	●	●		●	●			
permethrin (Astro™ and others)	●	●	●					●	●	●
spinosad (Conserve®)					●		●	●		
Alternative Products										
Bacillus thuringiensis								●		
insecticidal soaps	●	●	●		●					
pyrethrins	●	●	●				●	●		
neem (Bioneem®)	●							●	●	
rotenone							●			
Professional Use Only										
bifenthrin (Talstar®)		●	●	●		●		●	●	●
cyfluthrin (Tempo®)	●	●	●				●	●	●	
deltamethrin (Deltagard® and Suspend®)	●	●	●	●	●		●	●	●	
dicrotophos (Inject-A-Cide B®)	●					●	●			●
disulfoton (Di-Syston®)	●		●				●	●		
fenpropathrin (Tame®)	●		●		●					
fluvalinate (Mavrik®)	●		●			●		●	●	
imidacloprid (Merit®)	●	●	●				●		●	●
lambda-cyhalothrin (Scimitar®)	●	●	●	●	●		●	●	●	
oxythioquinox (Morestan®)					●	●				
pymetrozine (Endeavor®)	●									

For more information on this and other topics, see: **www.ag.ndsu.edu**

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