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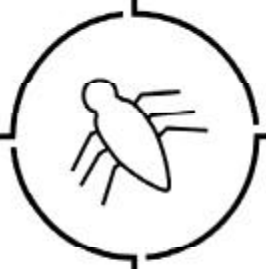
Insect and Disease Management Guide for Woody Plants in North Dakota



Marcus B. Jackson
Extension Forester

Phillip A Glogoza
Extension Entomologist

Janet J. Knodel
Crop Protection Specialist

Cheryl L. Ruby
Plant Pest Diagnostician

James A. Walla
Research Associate

NDSU EXTENSION SERVICE
North Dakota State University
Fargo, North Dakota 58105

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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.

How to use this guide

This guide describes management practices for common insects, mites, and diseases of trees and shrubs in North Dakota. Other pests and diseases may well be encountered. The pesticide use information in this guide is not intended for food-bearing trees and shrubs.

The first step in managing any insect or disease involves proper identification of the problem. When the identity of the host is known, the "Host Index" can be used to quickly identify common pests for that host. The common pests are described in detail, with management information, on the page number between parentheses in the host index. Chemical names of pest control products are listed for insect, mite, and disease problems. 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" for some of these pests. This section begins on 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, will often 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. These requirements can be addressed to attain the healthiest trees possible. Many measures that may be taken to improve tree health are already practiced by conscientious tree owners 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 trees will be killed by opportunistic insects and diseases.

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. Susceptibility to such stress can be reduced by selecting the right tree for a given location, using the appropriate planting technique, mulching, watering, not fertilizing, and providing protection from physical injury and sun scald.

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 should generally be labeled for USDA 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 particular tree species is desired, select the right location for that species. If a particular site needs trees, select species which 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 it is always necessary to secure trees to stakes whenever they are planted. This type of support is usually only necessary 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. Either organic or inorganic mulch may be used. 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. When soil is poorly drained, mulch should not be used.

Water

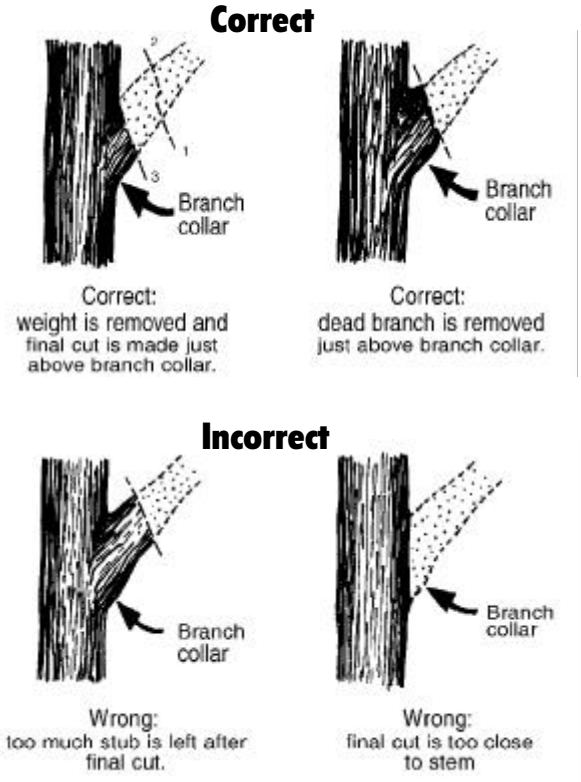
Too much or too little water seriously stresses newly planted trees and shrubs. The site should be thoroughly watered immediately after planting. Thereafter, the soil must be regularly monitored to prevent drying out. If rainfall is inadequate, the soil around the plant's roots should be deeply watered 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 watering is not needed at that time, while wet soil may indicate over watering. In particularly light soils or dry areas, a drip irrigation system should be considered. Water that is high in salts should be avoided when watering trees.

Fertilizer

Do not fertilize trees during the season when they are first 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 September 15, since such applications may result in growth which 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 is no longer 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.

Protecting Newly Planted Trees

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

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 subjected to a stressful environment. Many years can be added to a tree's life when stress factors are identified and mitigated.

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 are often damaged by chemicals, lawn-care equipment, and during construction activities. Damage to roots by trenching, soil compaction, de-icing salts, and herbicides may not become evident for several years after the incident occurred. Injuries from herbicides, de-icing materials, and other chemicals can be reduced by carefully choosing safe products and by applying them cautiously. Some physical injury to trees can be avoided by notifying construction and landscape maintenance people of tree-care priorities and by using mulch to keep lawn mowers, weed whippers, and other equipment a safe distance from the trees. Remove tree wraps and other materials which 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). Some diseases, such as cytospora canker on spruce, can be removed by pruning. 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., fireblight), and the disease-causing organism is present, the tools should be properly cleaned between each cut.

Fertilization

Soil fertility is seldom 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 availability is the most commonly diagnosed micronutrient deficiency of North Dakota trees. Too much fertilizer can also cause problems. Excess nitrogen fertilization has been proven to increase damage caused by certain insects and diseases 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 for plant survival and continued aesthetic performance. The host index can be helpful in identifying an unknown problem.

Rejuvenating Shrubs

Many decadent deciduous shrubs can be rejuvenated by cutting them back 4 to 5 inches above the ground and allowing 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 before a full complement of flowers is restored.

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 in 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 the hazard cannot be mitigated, those trees should be removed. Removal should also be considered if a tree no longer provides desired functions such as beauty, shade, or wind protection and cannot be restored to provide these functions.

Host Index

Host	Insect(s)/Mite(s)	Disease(s) and Disorders
Arborvitae	Fletcher scale (15), Spruce spider mite (21)	Winter injury (36)
Ash	Aphids (8), Ash bark beetles (8), Ash flower gall mite (8), Ash/lilac borer (9), Ash plant bug (9) Cankerworms (10, 11), Carpenterworm (11), European fruit lecanium scale (15), Fall webworms (15), Forest tent caterpillar (15), Redheaded ash borer (20)	Ash anthracnose (23), Ash rust (23), Ash yellows (24), Stem Decays (33), Verticillium wilt (35)
Aspen	Fall webworm (15), Forest tent caterpillar (15), Leaf miners, Poplar borer (19)	Armillaria root rot, Melampsora leaf rust (30), Poplar cankers (30), Septoria leaf spot (32), Stem decays (33)
Birch	Birch leafminer, Bronze birch borer (10), Fall webworm (15), Forest tent caterpillar (15)	Melanconium canker, Stem Decays (33)
Boxelder	Boxelder erineum gall mite (10), Boxelder bug, Boxelder twig borer (10), Cankerworms (10, 11), Cottony maple scale (12), Fall webworm (15)	Herbicide injury, Tubercularia canker (34), Stem decay (33)
Buckeye		Environmental leaf scorch (28)
Caragana	Blister beetles (9), Grasshoppers, Leafhoppers	Caragana canker, Schizophyllum sapwood rot (32), Septoria leaf spot, Stem decays (33)
Chokecherry	Chokecherry midge (12), Chokecherry pocket gall mite (12), Eastern tent caterpillar (13), Fall webworm (15), Prairie tent caterpillar (20), Uglynest caterpillar (22)	Black knot (24), Brown rot (25), Leaf curl, Stem decays (33), Valsa canker (35), X-disease (36)
Cotoneaster	Oystershell scale (18), Pear slug sawfly (18)	Camarosporium canker, Fireblight (28)
Cottonwood	Cottonwood leaf beetle (12), Fall webworm (15), Leaf miners, Poplar borer (19), Forest tent caterpillar (15), Poplar bud gall mite (19), Poplar petiole gall aphid (19)	Leaf and shoot blight (29), Melampsora leaf rust (30), Poplar cankers (30), Septoria leaf spot (32), Stem decays (33), Wetwood (36)
Crabapple	Fall Webworm (15)	Apple scab (23), Black rot (25), Cedar-apple rust (26), Fireblight (28), Frogeye leaf spot (25), Powdery mildew (31), Schizophyllum sapwood rot (32), Stem decays (33)
Elm	Cankerworms (10, 11), Carpenterworm (11), Cottony maple scale (12), Elm leaf beetle (13), Elm sawfly (14), European elm bark beetle (14), Forest tent caterpillar (15), Native elm bark beetle (17), Wooly elm aphid-see Aphids (8), European elm scale (14)	Botryodiplodia canker (25), Dutch elm disease (27), Elm black leaf spot (27), Elm wilt, Herbicide injury, Stem decays (33), Tubercularia canker (34), Verticillium wilt (35), Wetwood (36)
Hackberry	Hackberry nipplegall psyllid, Red-headed ash borer (20)	Hackberry Witches's-broom
Hawthorn	Pear slug sawfly (18)	Cedar-apple rust (26), Environmental leaf scorch (28), Fireblight (28)
Honeylocust	Cottony maple scale (12), Honey-locust pod gall midge (16)	Schizophyllum sapwood rot (32), Tubercularia canker (34), Winter injury

Host Index

Host	Insect(s)/Mite(s)	Disease(s) and Disorders
Honeysuckle	Honeysuckle aphid (16)	Powdery mildew (31)
Juneberry	Wooly elm aphid [on roots]	Black leaf and witches'-broom, Cedar-apple rust (26)
Juniper (Cedar)	Fletcher scale (15), Spittlebugs, Spruce spider mite (21)	Cedar-apple rust (26), Kabatina tip blight
Lilac	Ash/lilac borer (9), Oystershell scale (18)	Gray mold (28), Lilac witches'-broom (24), Powdery mildew (31), Stem decays (33)
Linden	Cottony maple scale (12), Forest tent caterpillar (15)	Environmental leaf scorch (28)
Maple	Cottony maple scale (12), Fall webworm (15), Maple bladdergall mite (16),	Eutypella canker, Iron chlorosis (29), Sunscald, Tarspot (34), Winter injury
Mountain-ash	Pear slug sawfly (18)	Apple scab (23), Black rot canker (25), Fireblight (28), Sun scald
Oak	Cankerworms (10, 11), Forest tent caterpillar (15), Numerous gall forming insects, Oak bullet gall wasp (17), Oak erineum gall mite — see Mites (17), Oak lace bug (17), Two-lined chestnut borer, Variable oakleaf caterpillar (22)	Oak anthracnose, Oak leaf curl, Powdery mildew (31), Stem decays (33)
Pine	Dioryctria moth (18), Introduced pine sawfly (16), Pine aphids, Pine needle scale (18), Spruce spider mite (21)	Sphaeropsis shoot blight (33), Sooty mold (33), Needle diseases, White pine blister rust, Western gall rust (35), Winter injury (36)
Plum	Chokecherry pocket gall mite (12)	Black knot (24), Brown rot (25), Phomopsis canker, Plum pockets (30), Powdery mildew (31), Shothole, Stem decays (33), Valsa canker (35)
Poplars	Carpenterworm (11), Cottonwood leaf beetle (12), Cottony maple scale (12), Forest tent caterpillar (15), Fall webworm (15), Poplar borer (19), Poplar bud gall mite (19), Poplar petiole gall aphid (19)	Marssonina leaf spot (29), Melampsora leaf rust (30), Poplar cankers (30), Septoria leaf spot (32)
Rose	Aphids (8), Rose leaf miners, Spider mites (20)	Gray mold (28), Powdery mildew (31), Rose black spot (31), Rose rust (32), Viruses
Russian-olive		Tubercularia canker (34), Phomopsis shoot blight
Spruce	Eastern spruce gall adelgid (13), Pine needle scale (18), Spruce budworm, Spruce needleminer (21), Spruce spider mites (21), Yellowheaded spruce sawfly (22)	Cytospora canker (26), Rhizosphaera needlecast (31), Winter injury (36)
Viburnum	Cecidophyes sp. mite, Dogwood borer	
Willow	Cottonwood leaf beetle (12), Elm sawfly (14), Poplar borer (19), Black willow aphid- see Aphids (8)	Cankers - see Poplar cankers (30), Leaf and shoot blight (29), Leaf rust, Stem decays (33)
Yew	Fletcher scale (15)	Winter injury (36)

Insect/Mite Management

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. There are as many as six generations annually. In late summer or early fall, a sexual generation is produced 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 is often 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 substantially damage plants. There are often natural predators present that will keep aphid populations at low levels. If an aphid population is becoming unacceptable, look to see if there are predators (ladybird beetles, lace wings, etc.) present. If present, it may be better to hold off on chemicals and allow nature to take its course. 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. Acephate and other insecticides may be injected into the tree by professional applicators.

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 head is partly or completely hidden by the thorax. Adult beetles overwinter in hibernation chambers in the rough outer bark on the trunk of an ash tree. There is 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 it is not known if 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. Under magnification, these mites can be viewed 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 widely

used in ornamental plantings. Heavy infestations do not negatively affect tree health 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 clearwing 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-June and lay their eggs on 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 1/4 inch in diameter. The area around entrance holes may die, producing target-like sunken areas. Boring causes dieback of limbs and may kill young trees. Infestation often occurs at injury sites such as those caused by lawn mowers, weed trimmers, or previous attacks by *Podosesia*.

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 are also infested. See "Maintaining Healthy Trees and Shrubs." Insecticides can be used by spraying the trunk and lower branches with permethrin or lindane 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 commercially available for monitoring and improving spray timing.

Pest: **Ash plant bug**

(*Tropidosteptes amoenus* and other *Tropidosteptes* spp.) family Miridae

Host(s): Green ash

Description/Biology: There are 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 1/2 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 it is normally not severe enough to cause defoliation or warrant control.

Comments: As numbers increase through the summer, damage to foliage can occasionally be significant. Control is justified when leaf injury is easily found 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 head or remainder of body ("neck-like"). 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. There is one generation per year. Adults emerge in late spring and early summer. Eggs are laid 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, and pouch-like 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 substantially damage the health of infested plants.

Comments: Earliest foliage is often 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 1/2 to 3/4 inch. Eggs are laid 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. New buds are attacked 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 1/2 inch long.

Damage/Symptoms: Newly hatched larvae skeletonize the undersides of leaves. By August, larvae bore into shoots. Entry holes are plugged by frass and silk. In the spring when larvae resume tunneling, the entrance hole and frass plug can be seen, 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 1/2 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 1 1/4 inches when fully grown. The life cycle may last from one to two years. Adults emerge from infested trees from late June until August. Eggs are laid in bark crevices of weak or dying trees. Limbs 1 inch in diameter or less are infested first, larger limbs and trunk 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 basswood, bur oak, elm, green ash, maple, white birch

Description/Biology: There is 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 3/4 to 1 1/2 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 mid-summer, 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 3/4 inch long, brownish gray, and do not have spines. Males are also brownish gray with irregular light bands on the forewings.

Damage/Symptoms: Feeding by young larvae 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. It's recommended to 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 basswood, bur oak, elm, green ash, maple, white birch

Description/Biology: There is one generation per year and they overwinter 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 has three pairs) and a pair of tubercules on the dorsal surface of the abdomen. Larvae are slender and about 3/4 to 1 1/2 inches long when mature. Larvae crawl via a looping behavior and are often blown by the wind as they hang from their own strands of silk.

Damage/Symptoms: As with the fall cankerworm, defoliation is caused by larval feeding. 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. It's recommended to 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. Though 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 are often found in trees which are of low vigor, but apparently healthy trees may be affected if there is 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. It is likely that the adults are active during bloom or early fruit set. Their small orange maggots develop in the fruit. Larvae remain in infested fruit, which dry up and drop 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 they appear 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. There is only 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: Pouch-like 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 1/4 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. Young foliage is preferred. 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. There is one generation per year.

Damage/Symptoms: Scale insects have piercing-sucking mouthparts that are inserted into leaf veins to draw out plant sap. Feeding can cause twig dieback. Severe infestation may kill major limbs. Honeydew, produced by the scales, coats the leaves and promotes the growth of black sooty mold fungi. In late spring, heavily infested branches with white egg sacs look like 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 aphid-like insects. There are 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 seriously harm trees.

Comments: Can apply a summer spray of soap or 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: There is 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. The tents are used 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 1/2 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 are usually not permanently damaged. 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 like 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, grub-like 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. There are usually two generations per year.

Damage/Symptoms: Larval feeding skeletonizes foliage, while adult feeding causes a shothole 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: Boiling water, light oil, or insecticides may be applied 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, basswood, elm, willow, other hardwoods.

Description/Biology: Mature larvae are 2 inches long and have wart-like 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. Mature larvae are 2 inches long and have wart-like bumps on their bodies. There is 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 are often 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 about 36 eggs are laid. Egg laying galleries are usually parallel to the wood grain. Larvae hatch from the eggs and bore larval galleries perpendicular to the egg laying galleries. There are usually two generations per year. The second generation of beetles overwinter 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, felt-like cocoon that resembles a rice grain and may have long filaments protruding from the posterior end. Females produce tough, felt-like white rings surrounding their oval, grey to brown body, giving them a mealybug-like appearance. When crushed, these scales exude red fluid. One generation is produced 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 mid-vein 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 over 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: The 1/4 inch in diameter, hemispherical in shape, and reddish brown protective cover of the female is the stage most often seen. Eggs are laid 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 mid-vein. 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. There is only one generation per year.

Damage/Symptoms: Large clusters of the reddish brown mature scales can be seen on branches and twigs. Sticky honeydew is produced, 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: There is 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 located at the ends of tree branches. As the colony grows, more leaves are added 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 are usually effective. When webs have formed, the nest should be opened up 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. There is 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. Honeydew is produced by the scales, coating the plant. Black sooty mold grows on the honeydew, contributing to plant stress.

Comments: The eggs hatch over 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, basswood, birch, cottonwood, elm, maple, oak, poplar, other hardwoods

Description/Biology: Similar to the eastern tent caterpillar. There is 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 1 1/2 inch. 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: Defoliation is caused by larvae. 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, webs do not develop.

Comments: Outbreaks typically last for two to four years in North Dakota. *Bt* works well to control young caterpillars, while permethrin or 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. Eggs are laid on young leaflets. The cream colored larvae feed on the leaf, stimulating the growth of a pod. The larvae feed within the pod. There are three to five generations per year.

Damage/Symptoms: Infested leaflets develop into a pod-like gall. There may be one or more larvae 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 infested trees are reduced in ornamental value.

Comments: Insecticide treatments, with spinosad or carbaryl, timed to coincide with spring growth, with 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 which 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, Miniglobe, and others. 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. There are two generations per year. They overwinter as prepupae 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: Defoliation is caused by larval feeding. 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 there are more than 10 larvae 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. There is 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 is rarely 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 are generally 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. There is 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 fan-like 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 have been recommended to 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. The American elm is most seriously affected by DED. 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 1/4 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. There is likely more than one generation 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 healthy trees are rarely damaged by their presence.

Comments: Oak trees have a number of gall-forming insects associated with them and they are generally 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. There are five nymphal stages. The nymphs are blackish with white markings and have spines on the abdomen. They mature to the adult form by midsummer. There are two generations per year, with the second generation completing development by fall. The adults are inch long. The wings of these true bugs have a lacelike appearance. The insect's 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 is rarely 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, chlorpyrifos, or malathion will kill crawlers; however, these chemicals will also kill natural enemies of the scale insects and could ultimately 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. There may be one or two generations per year, depending on the weather.

Damage/Symptoms: Defoliation occurs due to leaf skeletonization and premature leaf drop. There is usually little detrimental effect on the hosts, but the skeletonized leaves and the slug-like 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 1 1/4 inches is typical for this genus. Larvae bore into bark, stems, shoots or rust galls during the summer. Larvae are usually pinkish-green and up to 3/4 inch long. Pupation occurs during mid summer 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 may also 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 in Nebraska is obtained by spraying lindane during the second week of August. For greater control, a second spray may be applied in mid April. If acephate or dimethoate is chosen, two or three applications at 10- to 14-day intervals are required. Control with acephate or dimethoate is reported to be less consistent than with lindane. Permethrin may also 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 red crawlers or nymphs (1/80 inch) emerge and are dispersed by the wind to a new uninfested host or 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 spring. Most populations can be managed by keeping hosts healthy along with 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 longhorned beetles due to 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 are often referred to as roundheaded borers. The life cycle usually requires one to two years to complete, but three years may be required 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). Treat trunks and lower limbs of high value trees in late July with lindane as adults begin to emerge. Repeat at two-week intervals through August.

Pest: **Poplar bud gall mite**
(*Cosetacus para populi*) 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. There may be 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 the gall eventually encircles the base of the bud or shoot. Young galls are greenish; older galls are red to brown and cork-like. Old galls persist for several seasons.

Comments: Although trees are seldom 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, carbaryl can be sprayed 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 which 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. A generation is produced on the alternate host. In the fall, the winged aphids return to *Populus* spp. and a male and female generation is produced. One egg is then produced by each female.

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 sugarbeets, 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 properly identify them. Egg laying habits are the only indicator to differentiate the species in the field -- *M. americanum* have rounded egg masses which encircle twigs while egg masses of *M. californicum lutescens* do not encircle twigs and are deposited near the bases of hosts in the ground. There is 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 mid-summer. Adult moths are yellowish-brown, medium-sized (1 to1 1/2 inch 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. Defoliation is caused by the larvae. 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: There is usually 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 in color 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 over-winters 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. There is probably 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 will also kill natural enemies of the scale insects and could ultimately 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 positive identification is only possible by an expert. 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 may eventually 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: Mite infestations can be confirmed by

holding a white piece of paper under leaves and sharply tapping the foliage to dislodge the mites. Mites will be moving dots on the paper, or 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 diazinon, dicofol, and spinosad products are labeled for twospotted spider mites; however, these chemicals will also kill natural enemies of the mites and could ultimately make the infestation worse.

Pest: **Spruce needleminer**

(*Endothenia albolineana*) family Tortricidae

Host(s): Spruce

Description/Biology: There is one generation per year. The insect overwinters in the larval stage. In late May to late June, adults emerge from the puparium. Adults are small, brownish gray moths (1/2 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. There is usually only one larva per mine. Larvae are greenish in color with dark brown heads, and about 1/3 inch long. When fully mature, larvae will spin together groups of needles to form silken nests for overwintering.

Damage/Symptoms: Needles are killed by larval mining. 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. Larvae and adults can be dispersed by the wind. Females live for about a month and lay 40 to 50 eggs. The complete life cycle of egg to adult only takes 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 over 90°F, these mites will lay eggs and become dormant. Overwintering eggs are laid 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 is often 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 build-ups 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 (1-2% rate) may be used during the summer and dormant oils (3-4% 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. Do not use carbaryl or lindane for chemical control unless a specific mite-controlling chemical (acaricide) is added to the spray tank.

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

Host(s): Chokecherry and other hardwoods

Description/Biology: There is 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. There is 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. The eggs are laid in masses on the bark of host plants.

Damage/Symptoms: Chokecherry is the most common tree infested by the uglynest caterpillar. 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. Caterpillars may be controlled by pruning 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 1 1/2 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 which feed on variable oakleaf caterpillar eggs and larvae.

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. There is only one generation per year. Sawflies overwinter as cocoons. In late May to mid June, adults emerge, mate and females begin to lay eggs. A single egg is deposited at the base of a needle. Eggs hatch in five to10 days. Larvae are 1/8 inch when they first hatch. Mature larvae are 3/4 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: Defoliation is caused by larval feeding. 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 are 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, adequate control may be achieved by simply removing young larvae by hand. When an isolated ornamental tree is infested, spraying young larvae off of the tree with a strong jet of water will often 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 Management

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 which 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 are often corky, brown, and may cause disfigurement. Lesion diameter averages 1/2 inch, but they may coalesce and appear larger.

Comments: Clean up and destroy fallen leaves and fruit. Protectant fungicides can be used during prolonged wet weather, including chlorothalonil, propiconazole, thiophanate-methyl, myclobutanil, and mancozeb. There are resistant crabapple cultivars including, Centurian, Donald Wyman, Prairifire, and Spring Snow. Good air circulation between and within trees reduces 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 which may be retained in trees throughout winter. Under wet conditions in the spring, spores are produced that 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. Heavy defoliation may cause stunted growth and dieback. Small leaf spots with purple halos develop instead of blotches during less favorable weather. Orange or tan superficial lesions develop on infected twigs.

Comments: Raking and destroying fallen leaves may reduce infections in subsequent years. Fertilizing to promote growth (high nitrogen) will allow for optimum refoliation. In areas where trees are repeatedly infected by anthracnose, 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 buds 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 to complete its life cycle, ash and various species of cordgrass (*Spartina* spp.). *P. sparganioides* overwinters on grass species. Two rust spore types (spermagonial and aecial) occur on the ash in the spring and early summer. Aeciospores subsequently infect grass species, where the fungus overwinters and produces another spore type (basidiospores) in the spring that will infect ash.

Damage/Symptoms: Infection occurs on leaves, petioles, and green twigs of ash trees. The initial symptoms are yellow to orange spots on the upper leaf surface and chlorotic spots on the petioles and stems. 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 1/2 inch in diameter and the pathogen causes swellings of 3/4 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. Severe defoliation occurs in some locations under optimum conditions.

Comments: No control is needed on established trees. 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**
(*Phytoplasma fraxini*)

Host(s): Ash, lilac

Description/Biology: The disease caused by this pathogen is called ash yellows in ash and lilac witches'-broom in lilac. Phytoplasmas are bacteria that survive in the phloem of plants and are vectored (carried) by phloem-feeding insects such as leafhoppers. Once infected, hosts remain infected. Stress from insects, other diseases, drought, and other causes can hasten the decline of trees infected with *P. fraxini*.

Damage/Symptoms: Symptoms vary depending on the age of the tree, stage of disease, and differing levels of tolerance to the pathogen. Some of the symptoms that may be present on infected ash include subnormal leaf size, light 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. Currently, we do not know if ash yellows or lilac witches'-broom cause significant damage in North Dakota.

Comments: Green ash is a popular tree species in North Dakota and is often overplanted. 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 northcentral Iowa. White ash is generally less tolerant than green ash. Ash cultivars Bergeson, Dakota Centennial®, Patmore, and Autumn Applause were least affected. Evaluations are currently under way to determine if certain cultivars used in North Dakota are more resistant 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 are produced in the knots and may be windblown or rainsplashed to wounds or, more commonly, new green growth and cause new infections. *A. morbosa* grows under the bark and in nutrient and water carrying vessels for up to several months. Infected branches eventually swell, and spores are produced in these swellings during spring. Spores are produced at least one, but often two, years after infection. In the fall, swellings may occur on twigs infected that season. Occasionally, no symptoms will be observed until the next growing season, when the swellings begin to turn olive green with development of the fungus in the host tissue.

Damage/Symptoms: Olive-green corky swellings develop on twigs and branches the autumn or spring following infection. During the second season, these swellings become black and woody and can be enlarged to three times or more the diameter of healthy twigs and branches of the same age. The disease sometimes causes twigs to bend at the swellings. Trees may have one to many knots. Branches may be killed above knots, and trees with many infected limbs may be severely stressed.

Comments: Removing the knots, and 3 to 4 inches of healthy wood below the knot 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 when there are 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 fire-blighted twigs. Spores are produced in infected tree tissues in the spring and are usually released after budbreak, 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. 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. Leaf lesions are also susceptible to infection by other organisms and may take on fuzzy, irregular shapes or concentric ring patterns. Cankers (dark brown, sunken lesions) may appear on limbs of the tree. A canker may be only superficial on the bark or it may be in the wood, weakening the limb and possibly resulting in breakage during heavy fruit set or snow loads. Some branches may be girdled and killed by cankers. 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 storage rot.

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. Fungicides are rarely necessary. See "Maintaining Healthy Trees and Shrubs."

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

Host(s): Elms

Description/Biology: This fungus overwinters as cankers and primarily attacks stressed trees, invading through wounds. Spores are produced in fungal fruiting structures in the cankers all season long and spread by wind and rainsplash, 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. Leaves on American elms may turn bright yellow in mid to late summer and shed prematurely. This symptom can be 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." 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, spores are produced and carried by wind, rainsplash and insects 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: Infected leaves and shoots become brown as they are covered with spore masses. 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, felt-like 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. Captan may be used for control-

ling infection. 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 10-14 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, hawthorne, 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 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. Some types produce spores perennially thereafter.

Damage/Symptoms: On Rosaceous hosts, infection results in small yellow-orange lesions on the upper surface of leaves and young fruit. Orange droplets may form on these lesions. The infections expand to the lower leaf surface, where 1/16 to 3/16 inch diameter orange pustules are formed. 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. Junipers are usually not damaged by even high gall pressure, 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 should 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 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**

(*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 beginning in the lower crown. Often, sap oozes onto the cankered area and dries on the branches immediately below. The most characteristic symptom is the presence of individual dead branches. As a branch is dying, the needles will discolor to purple or brown before they drop off. If infected limbs are left on the tree, more branches 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 may eventually die.

Comments: Avoid wounding and overplanting (allow plenty of spacing between trees) and maintain good plant health. Prune out infected branches as soon as they are observed (best done during dry weather) or in winter. Cytospora cankers are often less severe on healthy trees. See "Maintaining Healthy Trees and Shrubs." While Cytospora cankers occur on all spruce species commonly planted around North Dakota, Colorado and Norway spruce are more susceptible than Black Hills spruce (and other white spruce varieties). Removal of damaged trees may help any remaining spruce trees to stay healthy.

Disease: **Dutch elm disease (DED)**
(*Ophiostoma ulmi*)

Host(s): Elm (all species)

Description/Biology: Dutch elm disease overwinters in infected elm trees or recently cut elm logs. The disease may be spread by beetles carrying the fungus that causes DED, by root grafts or through the aid of people. DED is commonly spread short distances from infected elms to healthy elms through root grafts, where the roots of neighboring trees grow together. The disease is spread over both short and long distances by the native elm bark beetle and the European elm bark beetle (See "Native elm bark beetle" and "European elm bark beetle"). These beetles may fly up to 1/4 mile in search of a feeding site or may be windblown for many miles. Another way that DED is spread is by transport of elm firewood. Adult beetles lay eggs in galleries between the bark and wood of weakened elm trees or recently cut elm firewood. If that wood was infected with *O. ulmi*, the fungus produces sticky masses of spores in egg and larval feeding galleries. When adult beetles emerge in the spring, they carry fungal spores on their bodies to healthy trees where they feed. The fungus grows in 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.

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 are often 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. 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 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. There are no economically feasible ways to reduce DED in natural stands. In an area where DED is present, elm wood should never 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 promptly cut down and debarked, burned, buried, or chipped and composted. After an infected elm is removed, trenching between the diseased tree and nearby (within a distance equal to the height of the infected tree) healthy elms may prevent transmission through root grafts. Fungicide injections, by trained professionals, have been effective in reducing the probability that trees will become infected, but they are expensive, must be repeated every three years and do injure trees. Thiabendazole and propaconizole are labeled for Dutch elm disease prevention. Therapeutic fungicide injections have not proven effective in North Dakota. Quick removal of infected elms to save neighboring trees is the most prudent and beneficial practice. DED usually kills only small to mid-sized branches of Siberian elm. Such infections can jeopardize sanitation programs because they are usually not detected. There are several cultivars of American elm and Asian elm species and hybrids that 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°F to 75°F. Secondary infections (from spores produced in spots caused by the first infections) 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 irregularly distributed 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 are usually 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 would typically remain dormant until the following spring. Continual infection, year after year, can cause eventual decline of trees.

Comments: Elm black leaf spot is rarely 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 "Winter injury of evergreens")

Host(s): Elm, linden, maple, poplar

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 winds, 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 can also result in the same symptoms when there is water available to the roots but they are starved for oxygen and begin to die. Soil compaction may also 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 there will be sufficient space for root mass expansion as the plants grow. If excavation, compaction of soil, or physical disturbance to the roots occurs, there may be little that can be done to correct the situation. In this case, supplemental water and fertilizer may be warranted to help the plants recover.

Disease: **Fireblight**

(*Erwinia amylovora*)

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

Description/Biology: Fireblight 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 this ooze is transported by rainsplash or insects 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.

Comments: Plant resistant cultivars and prune out cankers. It is essential to sterilize pruning tools between cuts to avoid spreading the bacterial pathogen to new cuts. Some sterilizing agents include 1/5 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 fireblight 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, hawthorne, juniper, lilac, pine, rose, viburnum

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 air-borne 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 is 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): Maple, 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. This deficiency may be caused by too little iron in the soil. It may occur when there is iron in the soil, but it exists in a form that is not available to the roots of some plants for absorption. This is often the case with alkaline soils in North Dakota.

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. Severe iron chlorosis may lead to scorched leaves (dieback from leaf margins), defoliation, branch dieback, and possible loss of the tree. Silver maple is generally very susceptible to this nutrient disorder, but some silver maples 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 will help reduce severity of symptoms. 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: **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 which 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 is seldom 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 of young trees.

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

Host(s): Cottonwood, poplar

Description/Biology: These fungi overwinter on the previous season's shoot growth and on fallen leaves. Spores are produced in these tissues during wet weather in the spring. These spores infect leaves and new shoots. Spores are produced in the new infections and rainsplashed 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 are usually lens shaped with white centers and black borders. Severe infections cause defoliation, but the disease is not usually 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 which infect aspen, cottonwood, or poplar leaves. Early-season and mid-season 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, these pustules will be covered by an orange to brown waxy layer that 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 are mostly 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 triadefon, help prevent infection. Avoiding monocultures of susceptible cultivars substantially reduces damage. Some cultivars (e.g., Norway, Robusta, and Imperial) are resistant.

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

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

Description/Biology: These fungi apparently overwinter as spores in buds and in 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. Fungal spores are produced 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 is often hollow, distorted, and enlarged, forming "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: It is not effective to manage this disease during the summer and fall. 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: **Poplar cankers**
(multiple fungal species including *Cytospora* spp., *Hypoxylon* spp., *Phomopsis* spp., and *Septoria* spp.)

Host(s): Aspen, cottonwood, poplar, other species

Description/Biology: These fungi generally overwinter in cankered tissues on branches and stems. Some also overwinter on fallen leaves. They generally infect trees through wounds and cause greater damage to trees under stress. Some of these fungi infect healthy bark and reside there as latent (inactive) infections; such infections allow the fungus to rapidly colonize branches of stressed or dying trees. Branches and limbs die as they are girdled by the expansion of the canker fungi. Tiny fungal fruiting bodies develop on the cankered bark.

Damage/Symptoms: Expanding areas of discolored bark radiate from infection sites. Peeling back the bark will reveal discolored sapwood. Infection sites may be at any wound that penetrates the bark and exposes the sapwood, such as those caused by insects, hail, or human activity around trees. As infected tissues die, the discolored area becomes sunken. Individual branches or entire trees may be killed. Leaves may remain attached to killed branches as the branches are girdled by the expanding canker.

Comments: Positive identification of canker fungi requires laboratory examination. Except for *Hypoxylon* spp., their presence does not establish their role as pathogens. Some canker diseases are more severe in nurseries where plantings are dense and excess nitrogen is used. Old poplar stands should be thinned before they begin to decline. Leaf diseases, such as Marssonina leaf spot and Septoria leaf spot, can weaken trees, causing them to be more susceptible to severe canker infections. Avoid wounding branches and stems. All poplars are susceptible to canker diseases; however, columnar European aspen, Assiniboine poplar, Tower poplar, white poplar and native cottonwood are believed to have

greater resistance than other species and cultivars. Quaking aspen is very susceptible to cankers, but the cultivar Pikes Bay is reputed to be more canker-resistant than the type species. No fungicides have reliably controlled these diseases. See "Maintaining Healthy Trees and Shrubs."

Disease: **Powdery mildew**

(several species of *Erysiphe, Microsphaera, Phyllactinia, Podosphaera, Sphaerotheca,* and *Uncinula*)

Host(s): Crabapple, currant, hawthorne, 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 becoming 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 is most often 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 include sulfur, thiophanate-methyl, triforine, and chlorothalonil. Avoid planting in the shade, watering the foliage, and excessive fertility. Promote good air circulation by properly spacing and pruning plants.

Disease: **Rhizosphaera needlecast**

(*Rhizosphaera kalkhoffii*)

Host(s): Spruce (especially Colorado)

Description/Biology: This fungus overwinters in infected needles on the tree and in fallen needles. In the spring, spores are produced in infected needles and are spread in splashing and dripping water. 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 has historically been a greater problem in eastern North Dakota than western areas of the state. The disease will often begin in the lower part of the tree, killing interior needles as it progresses up the tree. Needles will first 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% elongated and a second time soon 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: **Rose black spot**

(*Diplocarpon rosae*)

Host(s): Rose

Description/Biology: This fungus overwinters in fallen leaves or infected canes. Spores produced in the spring infect leaves only if the leaf surface is continually wet for seven hours, the relative humidity is high, and the temperature remains around 68 ^{0}F to 75^{0}F. Multiple cycles of infection can continue throughout the growing season when temperature and moisture are correct.

Damage/Symptoms: Large black areas (approximately 1/2 inch) appear on the upper leaf surface as circular spots that may coalesce into irregular spots with feathery margins. Small black dots (fungal fruiting bodies) may be visible in the center of the spots. Leaf tissue surrounding the spots may turn yellow and leaves often fall off the plant. On susceptible cultivars, raised and purplish blotches may appear on the first year canes. These will eventually become black. Heavy damage (defoliation, reduced growth, poor appearance) can occur when susceptible plants grow together.

Comments: There are different races of this pathogen. Roses which are not damaged by rose black spot in one location may be damaged in others. Disease can be reduced in susceptible cultivars by mixing the susceptible plants with resistant roses. If this disease has been a

problem, ask for resistant cultivars when purchasing new rose plants. Sanitation and cultural practices should be sufficient to manage this disease in resistant plants. Remove fallen leaves and prune canes that appear infected. Avoid a dense planting to promote good air circulation. Do not water excessively during periods of humid weather. Fungicides such as chlorothalonil, mancozeb, thiophanate-methyl, triforine, and wettable sulfur are readily available and effective, but may need to be used repeatedly if conditions favorable to infection persist.

Disease: **Rose rust**
(*Phragmidium* spp.)

Host(s): Roses

Description/Biology: There are as many as five spore stages for these rusts. These fungi overwinter on diseased leaves and stems. Disease develops as spores produced in the spring on overwintering pustules infect through natural openings on the leaves and shoots of the plant. Standing water on the leaves is required for infection to occur. Repeating spores are produced in these infections that cause additional infections throughout the growing season as long as moisture is available. When the temperatures begin to decline and day length shortens, the overwintering spore stage (raised, black lesions) forms on the leaves and stems.

Damage/Symptoms: Initial infections appear as yellow to orange pustules on the lower leaf surface and on shoots. As the disease progresses, orange to brown pustules develop on both the upper and lower leaf surfaces and on the stems. Toward the end of the season, the pustules develop a black, crusty appearance. When conditions are right for disease development, leaves may curl and drop from highly susceptible cultivars. Canes of normally hardy roses can die above stem infections by the next growing season.

Comments: Cultural and sanitation methods are usually sufficient for managing rose rust. Periodically scouting for and removing leaves with pustules on them will remove the source of new infective spores. Removing all old leaves in the fall or pruning out old material will eliminate the immediate source of the pathogen. For high value plantings where rust is a perennial problem, available fungicides include mancozeb, maneb, propaconizole, and triadimefon.

Disease: **Schizophyllum sapwood rot**
(*Schizophyllum commune*)

Host(s): Ash, caragana, little leaf linden, maple, mountain-ash, white poplar, willow, several fruit tree species

Description/Biology: This fungus overwinters in dead and diseased stem and branch tissues. It is a widespread organism that can aggressively colonize trees stressed by heat, drought, or major wounds, causing a white canker rot of the sapwood. After host infection and colonization, *S. commune* produces small (up to 2 inches wide), white, hairy shelf-like structures on the sides of trees. Spores from these structures enter hosts through openings such as sunscald lesions, freezing injury cracks, fire scars, dead branches, or stubs. Since this fungus colonizes stems which have been killed by other organisms and parasitizes other fungi, the presence of the shelf-like structures is not an absolute indicator that the fungus is causing damage to the tree.

Damage/Symptoms: *S. commune* can be identified by small (less than 2 inches wide), white, shelf-like structures produced in lesions or cankers on trunks or branches. Since this fungus may come in after other problems have affected trees, the extent of damage caused by *S. commune* can be difficult to determine. It can cause cankers, ultimately girdling trees, and does rot sapwood, which can structurally weaken trees.

Comments: The presence of this organism on a tree is often an indicator that the tree is seriously stressed. See "Maintaining Healthy Trees and Shrubs." Healthy trees may wall off infections. Avoid making large wounds. Remove trees if they become hazardous.

Disease: **Septoria leaf spot**
(*Septoria musiva*) also see "Poplar cankers"

Host(s): Aspen, cottonwood, poplar

Description/Biology: This fungus overwinters in fallen leaves from infected trees and in stem and branch cankers. During periods of wet weather in the spring, spores are released and wind-blown or rain-splashed onto leaves, branches, and stems to cause initial infections. Secondary infections occur throughout the growing season as more fungal spores are produced in infected tissues.

Damage/Symptoms: 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. Leaf spots are

commonly small and angular, sometimes coalescing to form large spots, but also may be circular and up to 1/2 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.

Comments: Leaf spots may first develop in early summer and widespread infection may occur by early August. Cankers rarely develop until after a few years of leaf infections. Cankers may be visible by mid to late summer, but are easiest to see after leaf drop (see "Poplar cankers"). Plant uninfected stock, remove highly susceptible varieties if they are damaged or threaten other varieties, and replant using resistant clones. Maintain plant vigor. Leaf litter cleanup in the fall is helpful. 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 excreted by sap-sucking insects (especially aphids). 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 that the fungi grow on. Control the underlying insect problem if necessary. Increased light or air circulation and reduced moisture will reduce sooty mold development. These fungi are rarely a concern for tree health but can cause aesthetic damage.

Disease: **Sphaeropsis shoot blight,**
also called Diplodia tip blight (*Sphaeropsis sapinea*)

Host(s): Pine

Description/Biology: This fungus overwinters primarily in infected cones and shoots. 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 seed cones are infected in late spring or early summer. The fungus develops rapidly in needles and shoots, usually killing the entire shoot before needles or shoots are fully developed.

Damage/Symptoms: New shoots are killed, and often have short, brown, dead needles. Resin-soaking of shoots is common. Branch tips, major limbs, and entire trees have been killed by this disease in other areas. It is usually 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 easily seen 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 not currently a major concern in established trees in North Dakota.

Disease: **Stem decay**
(many species of fungi)

Host(s): Nearly all woody plant species

Description/Biology: Most stem decay fungi produce mushrooms or conks (shelf-like or rounded woody growths) from decaying wood. They overwinter in or on infected wood. 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. Once they have an adequate food base they produce fruiting structures. Mushrooms produce spores in one season and then deteriorate, while conks may be annual or perennial. Perennial conks produce a new spore-producing layer each year. The spores are dispersed by wind. Spores that are deposited on exposed wood may infect that wood if substrate and environmental conditions are favorable (usually warm and wet). The fungi may grow in the wood for a few to many years before they cause substantial decay and produce fruiting structures. Most of the decay fungi are relatively host specific, but some infect many different host species.

Damage/Symptoms: The most obvious symptom is the fruiting structure; its presence indicates that the wood is decayed. Some decay fungi also cause cankers. If the tree is cut, the wood in the central part of the trunk will be relatively soft. Depending on the fungus involved, its color can range from white to yellow to dark brown. Trees that have been infected by decay fungi for a long time may be hollow. The most obvious damage occurs when the wood is structurally weakened and the tree breaks during a wind or snow storm. Some decay fungi may weaken the host by preventing transport of water and nutrients. Branch and top dieback are common in trees with advanced decay, but it is difficult to determine whether the decay caused the dieback of the decays was advance because the trees were stressed.

Comments: Aspen, boxelder, buffaloberry, caragana, cottonwood, green ash, plum, and willow are particularly subject to stem decay in North Dakota. If a tree is structurally weakened, it should be evaluated as to whether it would be a substantial hazard if it fell; if so, it should be removed. Otherwise, it is likely that there are so many infection sources that removal of a given tree would not markedly reduce the chances for infection of nearby trees. Reasonably healthy trees can contain (wall off) most decay fungi to the wood that existed when they were first infected (an exception is when canker-rot fungi are present). Then, any wood that develops subsequently will be sound. However, if the infected trees are severely stressed or wounded, the fungus can escape from the contained area to invade all the wood that is present at the time of the stress or wound. Therefore, maintaining good tree vigor and avoiding wounds is particularly important in dealing with trees that contain decay fungi.

Disease: **Tarspot**

(*Rhytisma acerinum*)

Host(s): Maple

Description/Biology: This fungus overwinters in tar-like spots on fallen leaves. In the spring, spores are produced that can infect new growth. New infections do not occur during late summer and fall. The infected leaves may be the last to fall, so the fruiting bodies are often on top of the leaf litter.

Damage/Symptoms: Typical leaf symptoms are irregular, circular, raised and textured black spots on the upper leaf surface that resemble tar. Often there will be a reddish or yellow halo around the spots. This disease is unsightly, but it is rarely injurious to the tree.

Comments: Raking up infected foliage may reduce the incidence of the disease in following years. This disease is rare in North Dakota. Fungicide treatments are not necessary.

Disease: **Tubercularia canker**

(*Tubercularia ulmea*)

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

Description/Biology: This fungus overwinters on diseased and dead branches and stems. Spores are dispersed in rainsplash, by adhering to birds or insects, or on horticultural implements. The fungus infects trees through wounds in the bark caused by factors such as adverse weather conditions, insect feeding, and frost injury. It may also enter through human-induced damage caused by pruning, weed control, and harvest implements.

Damage/Symptoms: As infected tissues die, the infected area becomes discolored and sunken. 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 fungal bodies develop on the infected tissues and usually turn black within two weeks. 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.

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

Damage/Symptoms: Sunken cankers form, and fungal spores are produced 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. The exudates may become black and hard or crusty as they dry.

Comments: These fungi typically colonize weak, wounded, or less vigorous hosts. 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. Try not to plant on poorly drained soils.

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

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

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

Damage/Symptoms: There are acute and chronic symptoms associated with this wilt disease. 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 symtoms 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. Green (in maple), dark brown, or black streaks may be observed in the sapwood of most species. When severe, this disease can kill branches or entire trees.

Comments: There is no control for Verticillium wilt. A tree may recover if good health is promoted by appropriately watering and fertilizing. 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): Hard pines (e.g., Ponderosa and Scotch)

Description/Biology: This fungus overwinters in galls on pine stems and branches. Spores are produced in galls for consecutive years. These spores infect developing needles and shoots in May and June. Galls will develop and usually begin releasing spores two years after infection. Western gall rust does not require an alternate host as do many rust fungi.

Damage/Symptoms: Roughly textured, elongate or roundish galls appear on branches and stems. In the spring of the second and subsequent years after infection, bright yellow-orange powdery spores appear on the surface of the galls. Branches may die above galls or witches'-brooms may form around galls, both of which deform trees. Trees may break at the point of stem infection. This disease can be very damaging in nurseries and can cause dieback and stunting in landscape and Christmas trees.

Comments: Managing the disease requires removal of galls from infected trees. Remove galls on infected trees from within 300 feet of a nursery growing susceptible stock, Christmas tree plantings, and other high value sites. 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.

Disease: **Wetwood,**

also called slime flux (bacterial species are often, but not always, associated with this disorder)

Host(s): Cottonwood, elm

Description/Biology: The bacteria that are normally 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 may also be transmitted from tree to tree by bark beetles or on pruning tools. Once present, the bacteria reside in older xylem tissue of tree indefinitely.

Damage/Symptoms: The most typical symptom is light gray (when dry) or dark brown or black (when wet) streaking on the trunk, caused by a bacterial ooze (slimeflux) that leaks out of openings, often in branch crotches or stubs. The exudate may be foul-smelling. The infected wood is dark-stained and somewhat weakened. The damage is mostly aesthetic as a result of the bark staining and odor. If the wood is used for lumber, its value is reduced.

Comments: There is no treatment 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.

Disease: **Winter injury of evergreens**

(See "Environmental leaf scorch" pg. 28)

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

Description/Biology: Reddish-brown dead foliage first seen on evergreen trees in the spring is often the result of injury sustained in 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 when a plant is unable to access moisture in the soil. Trees are then unable to take up enough moisture to replace water lost by the foliage. 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.

Damage/Symptoms: Since wind can accelerate water loss from foliage, desiccation is often directional toward prevailing winds. Winter desiccation may be greater near light colored surfaces (white siding, white rock mulch, etc.) or when trees are improperly planted, stressed by insects/diseases/other environmental factors, fertilized at an improper time, or have poor winter hardiness. Winter desiccation and early fall freezes generally kill foliage but buds and branches are mostly unaffected. Foliage killed by both early fall freezes and winter desiccation often remains green as long as temperatures are cold. Damaged needles then turn brown when temperatures warm up. Snow insulates needles, so damage may occur only above the snow line. New foliage usually emerges the following spring or early summer. Assessment of total injury should only be made after new growth has occurred. Winter injury is often an aesthetic problem in evergreens but does occasionally kill trees.

Comments: Only plant trees from a hardy source. The incidence and severity of winter desiccation may be reduced by watering trees adequately during dry periods, especially during late summer and fall.

Disease: **X-disease**

(Phytoplasma - a type of bacterium)

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

Description/Biology: The phytoplasmas overwinter in infected host plants and are moved from tree to tree by grafting and by leafhoppers. They live in the phloem (food conducting tissues of host plants) and cause a decline of susceptible hosts. Wild chokecherries and perennial weeds are natural host reservoirs, and the disease can move from them into new plantings.

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 fall coloration. There may be a second flush of growth 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. On sour cherries, fruits may be smaller than normal, pale red to greenish white, and pointed. It is common to see normal looking fruit on the same branch with symptomatic fruit. 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 currently available is planting disease-free stock and isolating plantings. Removal of all infected trees and all chokecherries within a radius of 500 feet has been shown to reduce disease spread in other regions. Inter-planting 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.

Pesticide Safety

Modified from: Pesticide Safety:
A Guide for Gardeners and Homeowners
NCR 590, June 1996
Julie Garden-Robinson,
Extension Specialist, Food and Nutrition
Greg Dahl, Pesticide Programs Specialist

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 it is your legal responsibility to read, understand and follow the label directions. Pesticide labels will usually 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.
- 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 must always 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 it is safe to reenter the treated area. ***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 there plants or animals that could be harmed by the pesticide? 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. It is illegal and unsafe to apply more pesticide than the label states.
- Use all chemicals in well-ventilated areas to avoid inhaling fumes. Work outdoors if possible. Use protective gloves and/or masks when recommended by label instructions.
- 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 1/4 full of water, covering tightly and shaking. Apply the rinse water on the original targeted area. Wrap the container in newspaper and send to the landfill or dispose 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 non-flammable absorbent material such as cat litter to soak up the spill.
- Place the material in a non-corroding 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 is needed 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 that is approved for pesticides may be needed for some pesticides that pose a risk from inhalation.

Clothing Clean-up

- Pre-rinse 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 without clothing through a normal wash cycle.
- Line-dry clothing (see Extension Publication HE-382, Guidelines for Safely Laundering Pesticide-Contaminated Clothing, for further information).

Application Equipment and Clean-up

- 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 a sprayer was used, rinse it with a small amount of water and spray over an area that may be legally treated. Clean the sprayer with water or as directed on the label. Rinse well and spray on an area that can be legally treated.
- 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 in order 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 inducing vomiting is recommended. 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	Cavalier
triadimefon	Bayleton, Accost, Strike
triflumizole	Terraguard
triforine	Funginex
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!**

('●' indicates listed pest is found on the pesticide label)

	Aphids	Plant Bugs	Leafhoppers	Scale Insects	Spider Mites	Gall Insects		Leaf Beetles	Caterpillars	Sawflies	Wood Borers
Synthetic Insecticides											
acephate (Orthene® and Isotox®)	●	●	●	●	●			●	●	●	
*diazinon	●	●	●		●			●	●		
*chlorpyrifos (Dursban®)				●				●	●	●	●
carbaryl (Sevin®)	●	●	●	●		●		●	●	●	
malathion	●	●	●	●		●		●			
dimethoate (Cygon®)	●										
dicofol (Kelthane®)					●	●					
methoxychlor	●							●		●	
lindane											●
horticultural oils				●	●	●					
permethrin (Astro™ and others)	●	●	●						●	●	●
spinosad (Conserve®)					●			●	●		
Alternative Products											
pyrethrins	●	●	●					●	●		
Bacillus thuringiensis									●		
neem (Bioneem®)	●								●	●	
insecticidal soaps	●	●	●		●						
rotenone								●			
Professional Use Only											
fluvalinate (Mavrik®)	●		●			●			●	●	
fenpropathrin (Tame®)	●		●		●						
disulfoton (Di-Syston®)	●		●					●	●		
imidacloprid (Merit®)	●	●	●					●		●	
oxythioquinox (Morestan®)					●	●					
cyfluthrin (Tempo®)	●	●	●					●	●	●	
lambda-cyhalothrin (Scimitar®)	●	●	●	●	●			●	●	●	
deltamethrin (Deltagard® and Suspend®)	●	●	●	●	●			●	●	●	
bifenthrin (Talstar®)		●	●	●		●			●	●	●

*Diazinon outdoor residential uses end in December 2004. Chlorypyrifos (Dursban® and other products) will no longer be approved for use beyond December 31, 2001.

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