IPED Field Guide

Pest Evaluation and Detection

United States
Department of Agriculture
Forest Service
Northeastern Area
State and Private Forestry
Newtown Square, PA 19073
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Credits

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The cover photo in the lower left was taken by David Bloniarz, U.S. Forest Service, Northern Research Station. The other two photos were taken by Donna Murphy, U.S. Forest Service, Northeastern Area State and Private Forestry.

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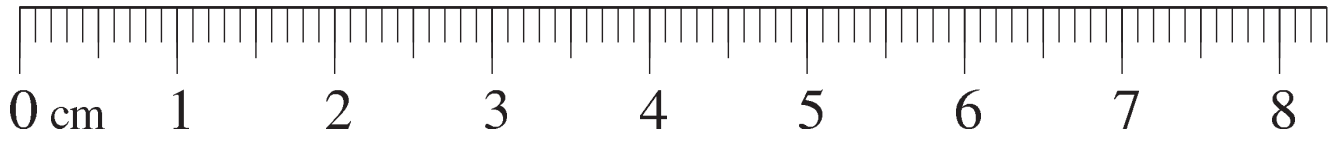
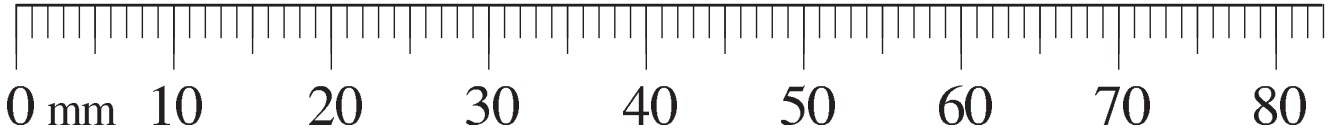
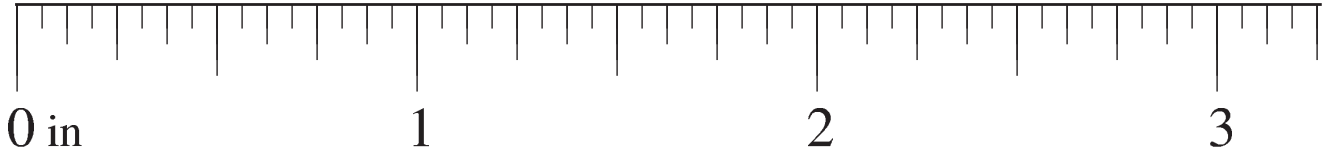
Scales







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Introduction

The Inventory Pest Evaluation and Detection (IPED) protocol provides a portable, accessible, and standardized method of observing a tree for possible insect or disease problems. It is intended to be a standardized protocol for long-term urban pest detection and monitoring throughout the United States.

This field guide will help you identify the signs and symptoms of tree stress, insect pests, and diseases, which will enable you to make informed, systematic decisions when collecting data using the IPED protocol. This guide is not intended to be used for diagnostic work, but rather as a resource guide for field use that corresponds with data entry fields for the IPED desktop and IPED PDA application found within the i-Tree Streets application at: *http://www.itreetools.org/*. An expanded version of this guide can be found online at: *http://wiki.bugwood.org/IPED*.

Background

Urban areas are frequently the first site of introduction for exotic pests, where they remain undetected until populations are well established and have harmful impacts on the health of host trees. Many communities routinely complete and update tree inventories, but often overlook pest invasions because pest detection tools are not part of the inventory process. Prior to the development of IPED, there were no processes in place for aggregating pest inventory data into a standardized form, which would allow communities to analyze pest trends otherwise difficult to detect across geographic or political boundaries.

Urban tree inventories are conducted by communities to better understand the structure, function, and management needs of their urban forests. Detecting tree pest problems during an inventory provides information that can lead to preventative actions that can save trees.

IPED is a tool for integrating field data collection and desktop reporting within the i-Tree suite of tools. i-Tree was created to develop, disseminate, support, and refine urban forest analysis tools and is utilized as the platform for IPED within the i-Tree v3.0 Streets application. For more information, see the field data collection procedures and desktop operation guide within the i-Tree Streets application at *www.i-treetools.org*.

Rationale

Since most exotic pests are initially introduced into urban areas (Asian longhorned beetle, emerald ash borer, and gypsy moth, for example), incorporating exotic pest detection into street tree inventories expands detection capabilities and enables communities to become a front line in the detection of exotic pests. IPED provides a portable, standardized method of observing a tree for signs and symptoms of possible insect or disease problems. Awareness of signs and symptoms that indicate potential tree health issues offers early opportunities for preventative actions and improved urban tree management. The rationale behind the field guide builds on the pretense that diagnosis is based largely upon determining signs and symptoms to narrow the range of possible causes of tree health issues such as stress, pests, or disease.

The protocol of using signs and symptoms when observing the foliage, twigs, branches, and boles of trees provides a methodical, systematic approach to pest detection. For the purpose of this field guide, *a symptom is defined as an injury by—or a plant's response to—a pest agent. A sign is defined as the pest organism itself, its skeleton, or a product produced by the pest. A sign is helpful in identifying the cause of a symptom.*

Tree Stress

Tree stress can result from mechanical, physical, or biological factors, or a combination of these. Factors that cause stress can be biotic or abiotic. Stress responses vary by cause and can include slow growth; sparse, undersized, or distorted, often ***chlorotic,*** nutrient-deficient leaves; browning of leaf margins; premature autumn color; premature leaf drop; and ***adventitious sprouts***. Two general sequences of symptoms are recognized. If decline is initiated by an event such as root cutting or severe defoliation, buds and twigs may die as a result of shock. If decline results from chronic stress, foliar symptoms and slow growth are likely to precede dieback.

Dieback

Crown dieback is the dying back of branches and branch tips generally in the upper and outer portions of the tree crown. Dieback often occurs as a sign of stress but may be associated with a new pest or disease. Crown dieback can be caused by a variety of factors including insects, disease, and environmental conditions. Branches that are defoliated by insects are not considered dieback. When conifers die back due to stress, they tend to lose needles from the inside of the crown out and from the bottom up.

Dieback of twigs or whole branches is often a symptom of either ***biotic*** or ***abiotic stress***, including drought, chemical injury, root injury, insects, or disease.

If you know that the observed dieback is caused by drought or other stresses, record it in the Tree Stress category. Otherwise it should be recorded under foliage symptoms.

Tree Stress

Dieback

Twig Dieback in upper/outer crown (> 10%), but not pervasive

Dieback of twigs in the upper/outer crown (>10%) can be an early indication of more severe problems such as physical damage to tree roots, root girdling, pollution, drought, soil compaction, or poor drainage. Although 10% dieback of the outer crown may not be detrimental to the health of a tree, it should be considered seriously and warrants a full health assessment. When conifers die back due to stress, they tend to shed needles from the inside of the crown out and from the bottom up.

Pervasive Twig Dieback throughout the Crown

Pervasive twig dieback throughout the crown is an indication that the health of the tree is compromised. Pervasive dieback can be a result of long-term drought stress, soil compaction, nutrient deficiencies, poor drainage, girdling roots, insect infestation, or disease.

Epicormic Sprouts

Epicormic sprouts, whether at the base of the tree, along the bole, or on branches, can be caused by topping, wounding, insect infestation, or disease. Epicormic sprouts are weakly attached to the stem. Weak branch attachments will eventually result in branches that are more prone to breakage and decay.

Twig Dieback in upper/outer crown (> 10%), but not pervasive—Maple in urban environment

Pervasive Twig Dieback throughout the crown

Pervasive Twig Dieback throughout the crown—Spruce decline

Epicormic Sprouts—Developing on ash after emerald ash borer attack

Wilted Foliage

If you know that drought or other stress factors are responsible for the wilt observed, record it here. Otherwise it should be recorded under foliage symptoms.

Wilt is caused by the loss of water pressure in a leaf, causing it to droop, curl, or lose its normal color. Wilt can be caused by insects, disease, or environmental factors such as drought, chemical damage, girdling, root damage, soil compaction, or construction damage. The pest may be located on the branch, twigs, or trunk depending on the time of day the inspection is conducted. Several diseases, such as oak wilt and mimosa wilt, cause foliage wilting. Dutch elm disease causes flagging, which is the wilting and dying of foliage on entire branches.

Wilt, Whole Crown

Wilting of an entire crown can be caused by abiotic or biotic factors. Abiotic causes are often associated with structural damage to the tree, water deficiency, and/or soil compaction. Biotic factors are often a cause of vascular disease. Vascular wilts are caused by ***pathogens*** that establish in the xylem and prevent water movement throughout the tree. Vascular wilts are usually fatal, although in some cases symptoms can be limited to branch mortality.

Wilt, Partial Crown

Partial wilting of the crown can be caused by abiotic or biotic factors. Abiotic causes are often associated with structural damage to the tree, water deficiency, and/or soil compaction. Biotic factors are often associated with pathogens that establish in the xylem. These pathogens prevent nutrients and moisture from moving throughout the tree. Vascular wilts are usually fatal although in some cases symptoms can be limited to branch mortality.

Wilt, Whole Crown—Oak wilt

Wilt, Whole Crown—Heavy wilt symptoms on oak

Wilt, Whole Crown—Pine wilt nematode

Wilt, Partial Crown—American elm

Wilt, Partial Crown—Crown wilt caused by Verticillium wilt

Tree Stress

Environmental Stress

Environmental stress contributes to many problems associated with tree health. Stressful environmental conditions such as extreme temperatures; poor soil; and physical damage to leaves, bark, and roots can predispose a tree to secondary insect and disease attacks.

Frost Cracks

Frost cracks are caused by differential expansion and contraction of woody stem tissues during extremely cold periods. Trees with thin bark are more prone to frost cracking. These cracks are usually found on the lower bole of the tree and are often associated with other tree defects such as cankers or pruning wounds. Other openings in trees can be caused by decay organisms that cause loss of wood by their actions.

Lightning Strike

Lightning injury is influenced by a tree's location, moisture content, and the amount of moisture in the soil around the tree. Damage can be correlated to where the tree is struck and the concentration of water in the tree. If the lightning strike is concentrated in the ***phloem*** between the bark and the wood, then the strike will follow this channel and create an explosive separation of the bark. If there is more moisture in the center of the tree, the explosion from within may blow the tree apart.

Hail Injury

Young trees exposed to hail typically develop small to large multiple wounds on the exposed side of the tree, damaging the bole and twigs, stripping the bark, and destroying the buds. If the number and size of the wound areas are too large, the tree may die or begin to decline. Older conifers and hardwoods typically have thicker bark, thus they typically suffer less severe damage.

Frost Cracks—Frost and winter injury on the bole

Lightning Strike—Oak

Lightning Strike—Damage on bole of oak

Hail Injury—Hail damage on bark of young peach tree

Hail Injury—Hail damage, cankering on shortleaf pine

Tree Stress

Environmental Stress

Sunscald

A variety of cultural practices, such as deep planting and trunk and root injuries, are suspected of being ***causal factors*** in the development of sunscald. A species characteristic thought to play a role in the development of sunscald is bark thickness. Young, thin-barked species appear to be more susceptible to sunscald but become less susceptible as they mature and develop thicker bark.

Broken Branches

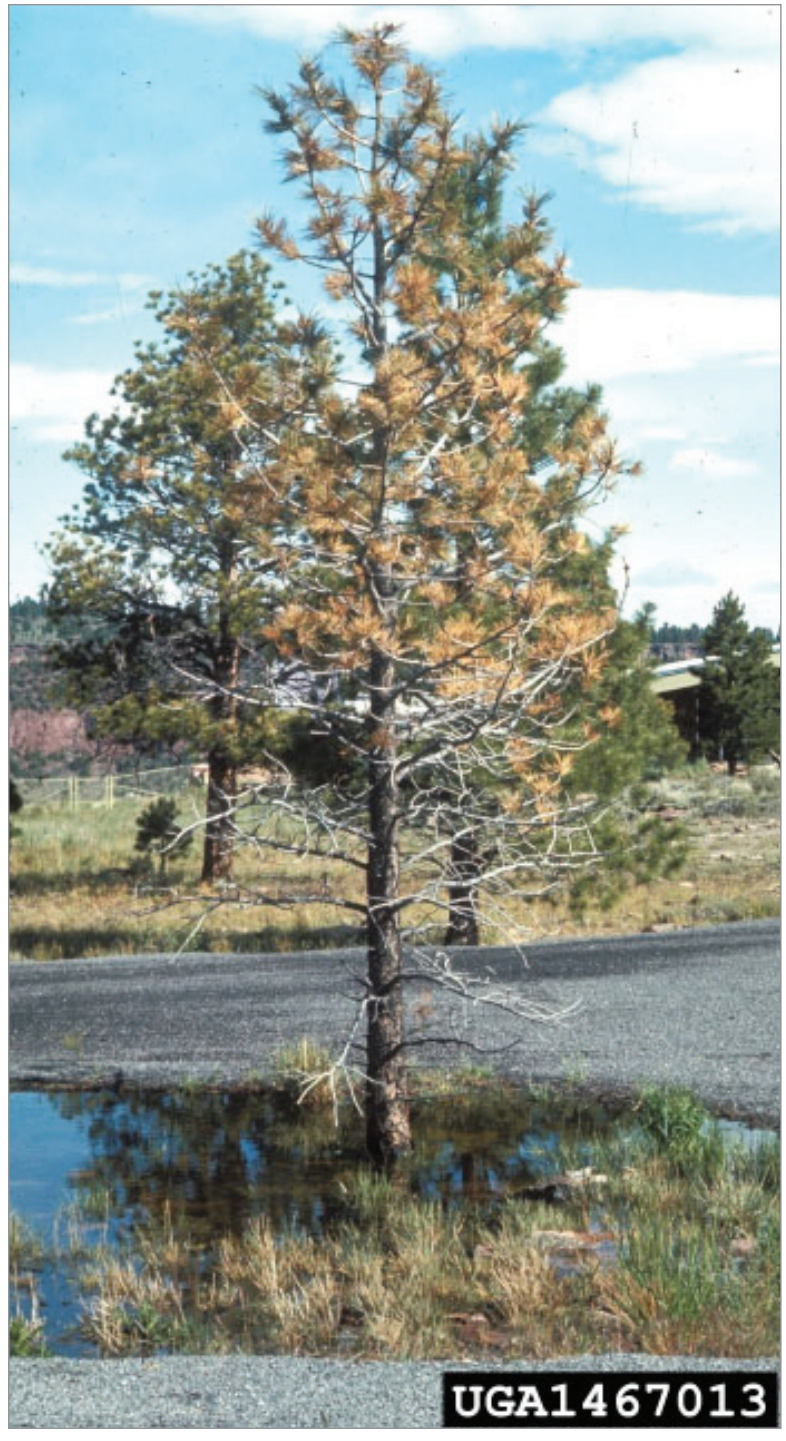
Trees should have a strong trunk with sturdy, well-spaced branches. The strength of the trunk/branch union depends on the relative sizes of the trunk/branches, the trunk/branch angles, and the spacing of the branches. Broken branches pose serious health risks to trees, contribute to property damage loss, and impact personal safety.

Flooding

Flooding can severely impact tree health. Injuries related to flooding can contribute to the introduction of diseases in tree roots and at injury sites. It can compromise the stability of a tree's root system and cause stress, resulting in tree decline and/or insect infestations and diseases.

Sunscald—Sunscald damage on one side of young tree

Broken Branches—Broken branch on pine



Flooding—Flooding-related symptoms

Tree Stress

Environmental Stress

Drought/Poor Soil

If you know that drought or poor soil is responsible for the symptoms, record it here. Otherwise it should be recorded under Signs and Symptoms of Foliage and Twigs, Subcategory Discolored Foliage (see page 22).

Drought contributes to tree stress, making trees more prone to insect and disease attacks. Drought stress can decrease resistance to trunk-invading organisms such as wood borers, fungi, and vascular diseases. Drought also limits nutrient availability by preventing the absorption of essential nutrients. A soil can be adequate for proper plant growth but compromised through compaction or poor drainage. Poor soil contributes to tree stress and manifests itself in many ways, including chlorosis/discoloration of leaves, stunted growth, or gradual dieback of the tree from the top down.

Human-Caused Stress

Human activities such as poor pruning, improper handling during transplanting, improper planting, construction damage, and the use of ***deicing salts*** or ***herbicides*** can damage trees directly or indirectly. Damaged trees can die suddenly or deteriorate over a period of time and are often at increased risk of failure as a result of wounding that does not heal properly. Trees with human-caused stresses are more susceptible to secondary damage-causing agents.

Drought/Poor Soil—Scorching of leaves due to drought damage on sugar maple

Drought/Poor Soil—Drought damage on pine

Drought/Poor Soil—Iron deficiency on oak

Drought/Poor Soil—Magnesium deficiency on leaf

Tree Stress

Human-Caused Stress

Topping/Poor Pruning

Topping is a pruning practice that harms trees and should not be used. Topping—the pruning of large upright branches between nodes—is sometimes done to reduce the height of a tree. Topping results in epicormic sprouting and contributes to branch death to the next lateral branch below. Poor pruning practices such as tipping, bark cutting, and flush cutting result in bark ripping and the dying back of branch stubs. Poor pruning also provides entry points for canker fungi that kill the cambium, and prevents or delays woundwood formation.

Poor or Restricted Planting/Mulching

Poor or restricted planting space can have detrimental impacts on tree health. Restricted planting space contributes to nutrient and water deficiencies caused by inadequate soil volume. It can also result in stress related to poor drainage; compromised root systems due to the inability of roots to penetrate compacted soil; girdling and encircling roots; and damage to sidewalks, pavement, and utility infrastructure.

Proper mulching of trees can provide organic material, prevent weed establishment, prevent lawn mower damage, and conserve water. Improper mulching techniques such as using noncomposted mulch can rob a soil of its nitrogen or induce nitrate-related burning of feeder roots.

Volcano mulching, the piling of mulch in a high mound at the base of a tree, can result in girdling of the tree due to the decay of bark where it is in contact with the mulch. Poor planting techniques often result in girdling roots if the roots of trees are not released from circular growing patterns at the time of planting, or the soil is too richly amended within the planting hole, thus contributing to circular growing roots that can become girdling roots over time.

Topping/Poor Pruning—Topping-caused epicormic branching

Topping/Poor Pruning—Flush cuts prevent the formation of woundwood

Poor or Restricted Planting—Decline

Poor or Restricted Planting—Decline

Poor Mulching—Improper volcano mulching

Human-Caused Stress

Wounding of Woody Tissues

Trees can easily heal small wounds. In urban areas, tree wounding is often caused by human activity related to the use of machinery, automobiles, lawn mowers, weedwackers, and vandalism that is repeated again and again on the same part of the tree. This constant wounding prevents a tree from fully healing wounds and is an entry point for pests and disease.

Salt/Chemicals

Salt injury occurs when salt is deposited by spray or ***drifts*** onto dormant stems and buds of deciduous woody plants and on the stems, buds, and leaves of evergreens. Injury may also occur when excessive amounts of salt accumulate in the root zone of plants. This buildup occurs along city streets, driveways, and sidewalks when salt runoff washes into the soil and when snow laden with salt is plowed and shoveled onto boulevards and lawns.

Chemical damage occurs when drift and misapplication of herbicides damage ***nontarget*** trees. The total extent of such damage remains unknown, but localized severe damage can occur. The causal agent is often identified through ***symptom*** expression and by determining the method and rate of nearby herbicide applications. Symptom expression can be variable for a given chemical and is often unreliable when used as the only diagnostic tool.

Wounding of Woody Tissues—Mechanical wound with resin

Wounding of Woody Tissues—Human activity

Salt Damage—Salt injury on aspen

Chemical Damage—Herbicide damage on dogwood

Signs and Symptoms of Foliage and Twigs

For most signs and symptoms observed, a threshold level of 10% should be exceeded prior to noting it in the IPED protocol. For example, a single caterpillar, with no evidence of defoliation or other injury, should not be reported. Symptoms on leaves, twigs, or branches not affecting >10% of the crown should not be reported. Minor mechanical injury on the stem and branches should not be reported.

Observe the foliage and twigs throughout the crown for signs of insect feeding, discoloration of the foliage, or abnormal growth of the foliage or twigs. Observing the exact nature of the feeding is often important in diagnosing the cause of the feeding even if no insect is present. For discolored foliage, the exact nature of the discoloration is also important.

Defoliation

Foliage eaten wholly or partially is generally referred to as defoliation. The extent of defoliation is often related to the severity of infestation. Foliage feeding can be recognized by the absence of foliage or from uneaten leaf or needle parts. Many insects feed by eating only the softer parts of leaves, resulting in a skeletonizing effect. Leaf miners bore inside the foliage and eat the tissues between the foliage surfaces, resulting in serpentine or blotchy areas. The adult Asian longhorned beetle has the somewhat unusual habit of sporadic feeding of the midrib portions of host leaves. Signs of this feeding may be detected through careful observation of foliage on potential host trees including maples, horse chestnut, birch, elm, poplar, and willow.

Defoliation, >10% of foliage, but not pervasive

Defoliation from any amount of feeding resulting in damage on 10% or more of the leaves/needles within a tree's crown meets the >10% defoliation threshold and should be noted in the IPED protocol.

Defoliation, >10%, but not pervasive—European hornbeam

Defoliation, sawfly defoliation >10% but not pervasive

Defoliation, >10%—Defoliation threshold must be determined by looking at the entire crown

Defoliation—If 10% or more of the leaves in the tree's crown look like this, it meets the >10% defoliation threshold

Signs and Symptoms of Foliage and Twigs

Defoliation

Defoliation, pervasive throughout the crown

Pervasive thinning of leaves in tree crowns is an indication of severe insect infestation and can result in severe stress. Signs of insects causing defoliation may or may not be present, so it is important to be aware of symptoms resulting from the presence of defoliating insects or diseases. It is important to look carefully and determine the feeding pattern of the insect on remaining leaves.

Trees commonly survive the first year of defoliation, although defoliation for one growing season can have an impact on future tree growth. Defoliated trees can grow new leaves later in the growing season, but the leaves are often stunted in appearance. Defoliation that reoccurs can cause tree death. Forest tent caterpillars and Eastern tent caterpillars often defoliate trees entirely, but leave telltale signs such as webbing and tents.

Leaf Mining, >10% of foliage, but not pervasive

Leaf mining is often recognized by the serpentine pattern of feeding beneath the leaf surface as insects live or feed within a leaf. Make sure the threshold of 10% is reached before noting it in the IPED protocol.

Leaf Mining, pervasive throughout the crown

Leaf mining is often recognized by the serpentine pattern of feeding beneath the leaf surface. The locust leafminer and elm leafminer are common pests throughout Eastern North America. Leafminer larvae tunnel through the leaf forming blotches and discoloration. As the miners move to the outer edge of the leaf, the leaf turns brown.

Defoliation, pervasive—Gypsy moth

Leaf Mining, >10% of foliage, but not pervasive—If 10% or more of all needles look like this, it meets the >10% defoliation threshold

Leaf Mining, >10% of foliage, not pervasive—Birch leafminer

Leaf Mining, pervasive throughout the crown—Elm leafminer

Signs and Symptoms of Foliage and Twigs

Defoliation

Chewing of the Midrib Only (any level)

Feeding along the ***midrib*** of host foliage can easily be missed unless carefully observed. The Asian longhorned beetle (ALB) will feed on the midrib. Pay particular attention to maples and other ALB hosts for this sign of insect feeding. If midrib feeding is observed, it must be immediately noted in the IPED protocol even if it does not meet the >10% defoliation threshold. It is important to then check for other signs or symptoms of ALB such as frass, exit holes, or dieback.

Discolored Foliage (>10% threshold)

Discolored foliage can be caused by pathogens, insect activity, nutrient deficiency, air pollution, disease, or natural processes such as leaf senescence. Careful observation of the pattern and location of discoloration on the leaves is key to identifying leaf problems. In most cases a 10% defoliation must be met for the IPED protocol.

Mottling, Spots, or Blotches

Mottling is spotting of leaves or needles in an uneven and undefined pattern, usually involving several different shades of color. Leaf spots are more well defined while blotches are usually larger and more irregular in form.

Marginal Scorching (browning) of Leaves

Burn-like damage to leaf margins can be the result of environmental stress or disease. ***Marginal scorching*** of leaves may be caused by pathogens, drought stress, nutrient deficiency, and some feeding insects. Oak wilt and bacterial leaf scorch cause marginal scorching in leaves.

Defoliation, ALB Chewing of the Midrib Only—Does not need to meet 10% defoliation threshold

Discolored Foliage, Mottling, Spots, or Blotches—Bacterial leaf spot symptoms meet 10% Defoliation threshold

Discolored Foliage, Marginal Scorching—Oak wilt

Discolored Foliage, Marginal Scorching—Dogwood anthracnose

Signs and Symptoms of Foliage and Twigs

Discolored Foliage

Interveinal Scorching (browning) of Leaves

Interveinal scorching is represented by discoloration in the tissues between the leaf veins. The veins themselves may remain green for some time, and are the last parts of the leaves to discolor. Interveinal chlorosis or scorching is often caused by air pollutants or chemical injury.

White Coating

White coatings on leaves can arise from the actions of both fungi and insects. Notable among fungi are the powdery mildew pathogens that produce a white material on the surface of leaves. This material on the leaf surface is actually composed of ***fungal tissue***, but the fungus also grows into the interior of the leaves, disrupting their ability to photosynthesize. Anthracnose diseases can also sometimes cause a white discoloration on the surface of ***necrotic leaf blotches***. Insects such as scales and adelgids often produce a white, cottony protective covering during the stage of their life cycles when they are immobile.

Black Coating (often sticky)

Sooty molds are caused by several fungi that grow on the surface of leaves, needles, bark, or even wood or concrete structures. The fungi grow on the exudations of honeydew-secreting, sucking insects, such as aphids. Honeydew is a sticky, sweetish substance that is a good substrate for the growth of several different fungi that have very dark mycelia. Although the fungi are not pathogenic to plants, they can cause stress by coating leaves with a heavy black coating and disrupting photosynthesis.

Interveinal Scorching—Ozone injury on maple

Interveinal Scorching—Bacterial leaf scorch

White Coating—Powdery mildew on oak

Black Coating (often sticky)—Sooty mold on rhododendron

Signs and Symptoms of Foliage and Twigs

Discolored Foliage

Complete Browning/Bronzing of Leaves or Needles

Browning or bronzing of foliage can be caused by insects, disease, or environmental conditions. An insect or disease relationship may not be obvious in the foliage. Several diseases, such as oak wilt and bronze leaf disease of aspen, cause foliage bronzing. Bronzing can also be caused by some types of mites, ozone damage, and/or pollution.

Complete Yellowing of Leaves or Needles

Complete yellowing of the leaves is called chlorosis. Chlorosis can be caused by insects, disease, nutrient imbalances, or environmental conditions. An insect or disease relationship may not be obvious in the foliage. If a pest is present, it may be located on the branches, twigs, or trunk. Complete yellowing of all foliage on a tree is often an indication of a problem in the root system. Conifers affected by the root disease pathogen *Armillaria*, or by root collar weevils, often turn completely yellow-green to yellow before they die.

Stippling

Stippling is small, white-spotted, speckled injuries on foliage caused by certain insects, mites, and viruses. In some cases it can be yellow or black, but it is generally white.

Yellow/Orange/White Pustules

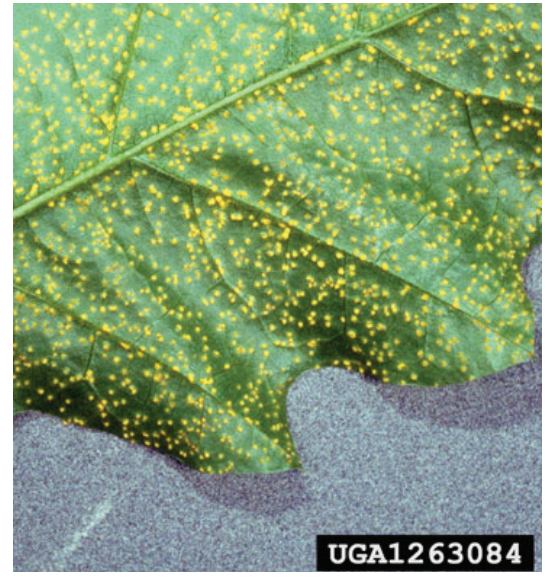
Yellow or orange-yellow, orange, or white spots on foliage are often caused by rust diseases. The pustules can range in color from off-white to orange. Both conifers and hardwoods are susceptible to a variety of rust diseases. Symptoms can occur from spring into fall, depending upon the disease.

Complete Browning/Bronzing of Leaves—Dutch elm disease

Complete Browning/Bronzing of Needles—Hemlock needle blight

Complete Yellowing of Leaves—Iron deficiency on oak

Stippling—Lacebugs



Yellow/Orange Pustules—Eastern gall rust on oak host

Signs and Symptoms of Foliage and Twigs

Abnormal Foliage

There are several foliage symptoms that do not involve discoloration or chewing. These include surface molds, distorted or curled foliage or twigs, and galls.

Foliage/Twigs Distorted (including galls on foliage)

Several insects and diseases can distort foliage and/or twigs. Distortion or stunting can be caused by aphids, shoot moths, cone worms, fungal pathogens, and bacteria. Distorted foliage can also result from herbicide injury. ***Leaf rollers*** are insects that construct shelters by rolling leaves with silk webbing. These rolled leaves may give the appearance of distorted foliage.

Several insects and diseases can cause shoot tips to curl. Curled tips develop during leaf or needle expansion due to a disruption in the physiology of the tissue. White pine weevil, spruce gall adelgid, and shoot blights caused by fungi commonly cause curling of shoot tips. Fire blight will also cause tip curling. This is referred to as Shepherd's Crooking.

Witches' Brooms Present

Witches' brooms are deformities in a tree that change the natural structure of branches or twigs. Witches' brooms often arise as the result of infection by mistletoes, fungi, insects, or disease.

Foliage Distorted—Eastern gall damage

Foliage Distorted—Cherry scallop shell moth

Galls on Foliage—Cooley spruce gall

Witches' Brooms—Hackberry

Signs and Symptoms of Foliage and Twigs

Insect Signs

Observe the foliage and twigs for the presence of insects. It is possible that the signs of insect feeding are present but the insect cannot be found. Some signs of insect presence include cottony masses created by aphids, small bags of foliage created by an insect within which it feeds, or webbing and/or tents.

Caterpillars/Sawflies feeding throughout the Crown

Caterpillars are mostly found on the foliage where they feed. However, occasionally caterpillars can be found within the branches even though they are feeding elsewhere on foliage. When caterpillars are found on twigs, shoots, or branches, look for signs of defoliation. Sawflies belong to the same group of insects as the wasps, ants, and bees. Sawfly larvae look like caterpillars. Some sawfly larvae curl up when touched and some feed in clusters.

Beetles feeding throughout the Crown

Not all beetles feed as adults, but some do, such as the elm leaf beetle. Asian longhorned and emerald ash borer beetles may be observed on the foliage or twigs even though they are not feeding.

Aphids/White Cotton pervasive throughout the Crown

Aphids are sap sucking insects. Severe infestations result when aphids can be found throughout the entire crown on twigs and shoots or young branches. Look for aphids on the twigs between the foliage. Some aphids, such as the hemlock woolly adelgid, cover themselves in a white cottony mass for protection. Sometimes aphids are discovered by the appearance of the foliage.

Sawflies—Larch sawfly

Beetles—Asian longhorned beetle adult

Beetles—Emerald ash borer adult

Aphids/White Cotton—Woolly adelgid

Signs and Symptoms of Foliage and Twigs

Insect Signs

Bags pervasive throughout the Crown

Small ***spindle-shaped bags*** hanging from the foliage or twigs are the protective feeding enclosures for some caterpillars. The bags are constructed from foliage and twigs. Bagworms are common on juniper, arborvitae, spruce, pine, and cedar. Severe infestations result when bagworms can be found throughout the entire tree.

Scale pervasive throughout the Crown

Scale insects often secrete a scale-like wax coating over their backs and can resemble bark. Most scales infest the twigs and smaller branches. The pine needle scale is a serious pest of ornamental pines. These scales can be found on the needles, especially of Scots and mugo pine. Severe infestations result when scales are found throughout the entire tree.

Tents/Webbing on more than One Branch

Silken tents are sometimes created as a protective barrier that an insect will feed in or use as a shelter. The Eastern tent caterpillar is a common example, as are the fall webworm and the uglynest caterpillar.

Bags pervasive throughout the crown—Bagworm

Scales—Hemlock scale

Scale—Soft scale

Tents/Webbing—Satin moth

Tents/Webbing—Fall webworm

Tents/Webbing—Eastern tent caterpillars

Signs and Symptoms of Foliage and Twigs

Percentage Foliage Affected

Considering the whole crown, how much of the foliage is affected by foliage feeding, discoloration, or abnormal growth?

>10% ;< 30% of the Crown Affected

>10-30% of the foliage or crown is affected by feeding, discoloration, or abnormal growth.

>30% but not the Whole Crown

More than 30% of the foliage or crown is affected but not the entire tree.

Whole Crown Affected

Defoliation can occur as a result of the feeding activities of insects or from disease. All of the foliage or the whole crown is affected.

>10%; <30% of Crown Affected—Cicada-caused flagging

>10%; <30% of Crown Affected—Gypsy moth feeding damage

>30% but not the Whole Crown—Oak wilt

Whole Crown Affected—Balsam woolly adelgid

Whole Crown Affected—Birch leafminer

Signs and Symptoms of Branches and Bole

Insect and/or disease presence may be detected by careful inspection of the woody portions of the branches and bole. Boring insects produce frass and sawdust that can be seen in bark crevices or on the ground. Exit holes are a sign of insect activity. Signs of disease may include ***fungal fruiting bodies*** or ***bleeding***.

Insect Signs

Signs of insect-caused problems include frass or sawdust resulting from boring, or entrance or exit holes. These signs may be difficult to see without careful observation. Insects boring into pine trees often results in ***pitch*** or ***sap*** seen on the bole or branches.

Frass Only

Frass is solid insect excrement usually consisting of a mixture of chewed plant fragments. Look for frass in bark crevices or at the base of the tree. Frass at the base of a tree may be a sign of insect feeding within the foliage.

Sawdust

Wood-boring insects often produce what is essentially sawdust as they bore into the tree bole or branches. This sawdust can be found in bark crevices or at the base of the tree. For some ***ambrosia beetles***, the sawdust appears almost like a toothpick sticking out from the tree bole.

Pitch/Resin Exudation

Pitch or resin ***exuding*** from the bark is often seen on conifers as a result of insect activity, wounds, or disease. Don't confuse it with sapsucker damage. Sapsucker damage usually occurs in lines across or down the bole while pitch flowing from insect activity appears randomly across the bole.

Frass—Asian longhorned beetle

Frass—Pine webworm

Sawdust—Carpenter ants

Sawdust—Sawdust from boring of the striped Ambrosia beetle

Pitch/Resin Exudation—Red pine shoot moth

Pitch/Resin Exudation—Pitch tube from spruce engraver

Signs and Symptoms of Branches and Bole

Insect Signs

D-Shaped Exit Holes

D-shaped exit holes are caused by a group of insects known as ***buprestid*** *or* ***flat-headed beetles***. They produce oval to flattened tunnels within the bark and create a D-shaped exit hole as they exit the tree. The emerald ash borer and the oak splendour beetle both produce a D-shaped exit hole that is only about 6 mm across and can be difficult to see without careful observation of the tree bole. Trees with dieback should be examined for exit holes. Check ash and oak for D-shaped exit holes.

Pencil Round or Oval Exit Holes (>=2 mm)

Round exit holes in the branches or bole are created by insects as they leave the tree. Round-headed borers such as sawyers and two common ash borers—the banded ash borer and the red-headed ash borer—produce small, round exit holes. The Sirex woodwasp also produces a round exit hole (in pines) as does the Asian longhorned beetle (check maples carefully).

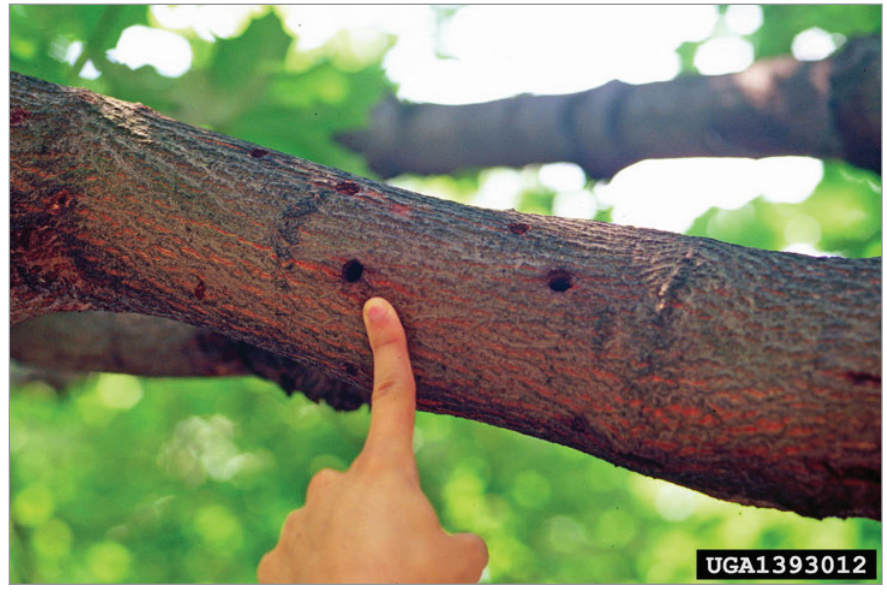
Shot Holes (<2 mm)

Small beetles exiting a tree may leave tiny holes in the bark. A good example of this is small holes created by emerging ash bark beetles.

Other Holes

There are many different types of holes made by insects in the branches and bole. If the holes found do not appear to fit into any of the above hole categories made by insects, please note here.

D-Shaped Exit Holes—Emerald ash borer



Pencil Round or Oval Exit Holes—Asian longhorned beetle

D-Shaped Holes—Bronze birch borer

Pencil Round or Oval Exit Holes—Sirex woodwasp exit holes

Shot Holes—Southern pine beetle exit holes

Signs and Symptoms of Branches and Bole

Insect Presence

Look for insects on the bark or the base of the tree. While caterpillars are most often found in the foliage, some may be crawling on the bark looking for a ***pupation*** site. Beetles may be searching for egg-laying sites. If you see ants, only the larger carpenter ants are of concern. Other signs of insects on the branches and bole include egg masses.

Caterpillars

Caterpillars feed on foliage in the tree crown. Caterpillars found on tree branches and the bole are moving to a resting site or hiding.

Beetles

Beetles can be found on the branches and bole. Females may be searching for egg-laying sites, or the adult beetle may be emerging from an exit hole.

Aphids

Aphids are generally found on new growth and smaller twigs.

Scale

Scales are generally found on the smaller branches and twigs, or on the bole of smooth-barked trees. A large scale infestation may exist before damage is obvious.

Caterpillars—Eastern tent caterpillar

Beetles—Asian longhorned beetle

Beetles—Adult emerald ash borer

Aphids—Hemlock woolly adelgid

Scale—Wax scale

Signs and Symptoms of Branches and Bole

Insect Presence

Carpenter Ants

Carpenter ants make nests in wood by chewing sandpaper-smooth tunnels and chambers into the wood of trees. They feed on protein and sugar, mainly feeding on insects and sugars produced by aphids and scale insects. A common misconception is that carpenter ants eat wood. They do not eat wood but rather remove wood as they create galleries and tunnels, often impacting the structural integrity of trees and buildings. Wood is discarded as shredded fragments of coarse sawdust ejected from the nests. The sawdust may contain dead ants and bits of dead insects that the ants have eaten.

Disease Signs

The structures produced by pathogens are referred to as disease signs. These can include ***sporocarps*** (mushrooms, conks, or other fruiting bodies), spores, and specialized vegetative and reproductive structures. Disease symptoms are the various responses by the host that are the result of the disease agent attacking the tree.

Decay

Wood decay is a common occurrence among trees. Decay can affect the roots, sapwood, or heartwood of a tree. Some trees may appear to be healthy, yet have extensive decay. Trees with extensive decay are structurally weakened. Nearly all wood decay is caused by fungi. Mushrooms, sometimes called conks, are usually seen growing on the sides of trees. These are reproductive structures, commonly known as fungal fruiting bodies. Trees are usually infected for many years before mushrooms are visible.

Ants—Carpenter ants in cavity

Ants—Carpenter ant

Ants—Carpenter ant and associated feeding woodpecker damage

Decay—Decay cavity

Decay—Decay of branches and bole

Signs and Symptoms of Branches and Bole

Disease Signs

Conks

Conks are spore-producing structures of some fungi that cause wood decay. Conks include structures that are hard and woody, or relatively soft and fleshy, as well as ***bracket fungi*** that are thinner and more flexible. Conks can be found individually, or in masses, but always grow on wood.

Fleshy Mushrooms

Mushrooms are often prominent signs of plant disease and are some of the largest fungal fruiting bodies. Many mushrooms grow on wood and most that do cause wood decay. The extent of decay varies widely with each fungus.

Cankers

A canker is a localized, often sunken, dead area on a twig, branch, or bole.

Bleeding/Slime Flux

Slime flux is associated with several bacteria, and is an exudate that is composed of sap and bacteria. Slime flux often has a distinctive sharp odor of fermentation, and is the result of a bacterial infection of the ***heartwood*** area of the tree known as ***bacterial wetwood***. Bleeding on branches and stems may be caused by insect attack as well as infection by fungi and bacteria. Bleeding on the stem is often the first sign of canker disease.

Conks—Artist's conk

Conks—Red-belted polypore (fungus)

Fleshy Mushrooms—Oyster mushroom

Cankers—Nectria canker

Cankers—Butternut canker

Bleeding/Slime Flux—Slime flux associated with bacterial wetwood

Signs and Symptoms of Branches and Bole

Disease Signs

Resinosis/Gummosis

Resinosis is an accumulation of pitch in conifers that often arises as the result of insect or pathogen attack. Resinosis can occur anywhere on the woody portions of a tree. When the pitch from resinosis is present at the base of a tree, it often becomes mixed with soil, forming a hard, sticky substance that discolors the soil. ***Gummosis*** is the production of gummy substances on hardwoods, often in fruit trees, on the surface of the bark.

Woody Galls or Burls

Woody galls or burls form on woody plants and are usually caused by bacteria invading the plant and affecting DNA. These galls can be found on tree trunks or on branches, and look like odd, corky balls. Pruning them away is the only cure.

Reference: Sustainable Urban Landscape Information Series (SULIS) *http://www.sustland.umn.edu/maint/tree_disease.html*

Problem Location

Branches

Are the signs or symptoms of insects or disease found in the main branches?

Bole and/or Root Collar

Are there symptoms or signs of insect and/or disease on the tree bole from the root collar up to the branches?

Resinosis/Gummosis—Gummosis caused by lesser peach tree borer

Resinosis—Sirex woodwasp boring symptom

Galls—Cynipid gall wasp

Gall—Crown gall on cherry bole

Burl—Burl and decay on pine bole

Disease Signs—Burl and decay on bole

Signs and Symptoms of Branches and Bole

Loose Bark

Loose Bark

Loose or flaking bark may be a sign of serious problems within the tree. For example, a tree infested with bark beetles, wood-boring insects, or root and butt decay may have loose bark. Woodpecker feeding resulting in ***bark sloughing*** is a sign of an insect-infested tree. Sunscald and other physiological problems can also cause loose bark.

Rhizomorphs Present

Rhizomorphs are shoestring-like structures produced by some root disease fungi. Rhizomorphs are usually dark-colored, tough structures that grow under the bark or in the soil. When they encounter a susceptible host, the rhizomorphs try to penetrate the bark and infect the host.

Mycelial Fans or Pads Present

Mycelial fans or pads are wefts of tissue produced by fungi, usually found under the bark. Most are white or buff colored. Although mycelial fans are produced by several species of fungi, those produced by *Armillaria* spp. are probably most common.

Insect Boring or Galleries causing Loose Bark

Boring insects attack both healthy and unhealthy trees. Larvae tunnel beneath the bark producing tunnels or galleries, which create entryways for pathogens that can cause structural weakness in the branches or bole. Woodborers can be detected in a number of ways: they can be heard feeding, frass and exit holes may be present, larvae may be exposed by peeling the bark, and feeding galleries and/or holes leading into the sapwood can be exposed by peeling back the bark. In severe infestations, the bark may be loose and peeling due to the galleries.

Loose Bark—*Armillaria* root rot

Rhizomorphs—Rhizomorphs of *Armillaria* root rot

Mycelial Fans—Mycelial fans of *Armillaria*

Insects Boring—Emerald ash borer

Insects Boring—Southern pine beetle galleries

Notes

Glossary

aphids—small plant-eating/sucking insects that cause great damage to cultivated plants. Members of the order Homoptera that undergo simple metamorphosis and whose larvae somewhat resemble adults without wings

abiotic stress—impact on trees caused by non-living factors

adventitious roots—roots that arise at sites other than in the soil, such as roots originating on stems or leaves

adventitious sprouts—sprouts that develop on the trunk or branches that are often a result of poor pruning, injury, or boring insects

ambrosia beetles—beetles of the weevil subfamilies that live in symbiosis with ambrosia fungi and cultivate fungal communities that provide their sole source of nutrition

bacteria—a large group of unicellular microorganisms that have a wide range of shapes and are capable of living in all organic lifeforms

bacterial wetwood—a common disease that affects the wood and bark of trees, characterized by water-soaked wood and a liquid that bleeds from wounds and becomes slimy, resulting in a condition known as slime flux

bark sloughing—the casting off of bark related to tree disease or stress

biotic—relating to, produced by, or caused by living organisms

bleeding—the production of sap/fluid in response to disease, insects, or wounding

bole—the trunk of a tree

bracket fungi—shelf fungi that produce shelf or bracket-shaped fruiting bodies (conks) and range from a single row of a few to dozens of caps

buprestid—a family of beetles with a long, flat, metallic-colored body and larvae that are harmful to woody plants

cambium—the cambium layer is found directly beneath the bark on trees and is surrounded on the outside by phloem and inside by xylem

canker—a localized, often sunken, dead area on a twig, branch, or bole

causal factor—anything that causes a disruption of a plant's normal growth

chlorosis—complete yellowing of leaves

chlorotic—plant tissue that appears pale green to yellow

conks—spore-producing structures of some fungi that cause wood decay

defoliation—foliage eaten wholly or partially

deicing salts—salts used for ice and snow removal that are harmful to trees and result in abnormal foliage color, needle tip burn, and marginal leaf burn

drifts—when herbicides or pesticides are moved by wind or other factors from an intended target to a nearby nonintended target

epicormic sprouts—shoots that arise from latent or adventitious buds that occur on stems and branches or from suckers at the base of the tree

exit holes—the holes left by young adults as they leave the tree after the larvae of insects pupate and adults hatch

exude—to discharge slowly

flagging—the yellowing or wilting of foliage on a branch that commonly occurs with a number of tree diseases

flat-headed beetles—beetles in the family Buprestidae that are beautifully marked, metallic colored, vary in size, and are somewhat flattened and boat shaped. Although they are beetles, they are referred to as borers because of the damage they cause in trees

fleshy mushroom—the spore-bearing fruiting body of a fungus typically produced above ground on soil or on its food source

flush cut—pruning cuts that originate inside the branch bark ridge or the branch collar, causing unnecessary injury to stem tissue

frass—solid insect excrement usually consisting of a mixture of chewed plant fragments

frost cracks—cracks that are caused by differential expansion and contraction of woody stem tissues during extremely cold periods

fungal fruiting body—a fungal structure that produces spores (see "sporocarp")

galls—plant tissue that has developed as the result of feeding or other activity of insects or mites

galleries—series of tunnels created beneath the bark in the cambium by wood boring insects

gummosis—an accumulation of pitch in conifers that is often the result of insect or pathogen activity

heartwood—nonliving xylem cells that form a core of wood in the center of the stem that provides the structural strength in trees

herbicide—a chemical substance or cultured biological organism used to kill or suppress the growth of plants

honeydew—a sticky, sweet substance that is a good substrate for the growth of several different fungi that have very dark mycelium

interveinal chlorosis—yellowish discoloration of green tissues in areas between the leaf veins that is usually related to lack of chlorophyll production due to disease or stress

interveinal scorching—the discoloration in the tissues between the leaf veins

leaf mining—the serpentine pattern of feeding beneath the leaf surface as insects live or feed within a leaf

leaf rollers—insects that construct shelters by rolling leaves with silk webbing

marginal scorching—dead tissues on the margins of leaves that result in browning and shriveling of foliage

midrib—the midvein of a leaf or leaflet

mottling—spotting of leaves or needles in an uneven and undefined pattern, usually involving several different shades of color

mycelial fans—wefts of tissue produced by fungi, usually occurring just under the bark

mycelium—mycelium (plural mycelia) is the vegetative part of a fungus, consisting of a mass of branching, thread-like structures

necrotic leaf blotches—varying degrees of dead areas or spots on leaves, often used to describe brown spots left by insects or disease

nontarget—not the intended target; term related to chemical applications when drift from herbicides/insecticides/fungicides causes damage to adjacent nontarget vegetation

parasitic plant—derives some or all of its sustenance from another plant. Parasitic plants have a modified root that penetrates the host plant and connects to the xylem, phloem, or both

pathogens—biological agents that cause disease or illness to their host. Soil contamination has the longest or most persistent potential for harboring a pathogen.

pervasive twig dieback—twig dieback that spreads throughout every part of the tree

pitch—a highly viscous liquid that appears solid; also known as resin

phloem—in vascular plants, phloem is the living tissue that carries organic nutrients, particularly sucrose, a sugar, to all parts of the plant

pupation—period in the life cycle of an insect when the adult structures are formed and the larval structures are broken down

pustule—an abscess or eruption

resinosis—exudations of pitch on the tree, often associated with fungal infection of the roots, bole, or branches, or with root collar weevils

rhizomorphs—shoestring-like structures produced by some root disease fungi

sap—phloem and xylem fluid released from a tree due to the buildup of pressure in sapwood that is released through wounds or openings

sapsuckers—birds within the woodpecker family that drill holes in the bark of trees while looking for insects to feed upon

sawflies—sawflies belong to the same group of insects as wasps, ants, and bees

scorching—dead tissues on the margins of leaves or between veins that result in browning and shriveling of foliage

shot holes—tiny holes found in the bark caused by beetles exiting a tree

sign—the physical evidence of a causal agent

skeletonizing—the lacy effect on leaves created by insects feeding on only the softer parts of leaves

slime flux—slime flux is associated with several bacteria and is an exudate that is composed of sap and bacteria

spindle-shaped bags—small, spindle-shaped bags hanging from the foliage or twigs that are the protective feeding or reproductive enclosures for some caterpillars

sporadic feeding—feeding by insects that occurs irregularly or at intervals that have no apparent pattern but can cause significant injury to plants

sporocarp—a specialized structure with the primary function of producing and releasing spores.

stippling—small, white-spotted, speckled injuries on foliage caused by certain insects, mites, and viruses. In some cases it may be yellow or black

symptom—a plant's reaction to a causal agent

webworm—a caterpillar that spins a web in which it feeds or rests

wilt—the loss of water turgor pressure in a leaf, causing a leaf to droop, curl, or lose a degree of its normal color

witches' brooms—deformities in a tree that change the natural structure of branches or twigs. They often arise as the result of infection by mistletoes, fungi, insects, or disease

wefts—threadlike or weaved as often seen with mycelial fans, usually occurring under the bark

Other Resources

Project Links:

IPED Protocol Home Page *http://pest.itreetools.org/*
IPED Online Resources *http://wiki.bugwood.org/IPED*

Resources:

U.S. Forest Service, Forest Health Protection, Northeastern Area State and Private Forestry, *http://www.na.fs.fed.us/fhp/index.shtm*
U.S. Forest Service, Forest Pest Alerts *www.na.fs.fed.us/pubs/palerts.shtm*
National Plant Diagnostic Network (Diagnostic Laboratory, First Detector Training) *www.npdn.org/DesktopDefault.aspx*
APHIS – Animal and Plant Health Inspection Service *http://www.aphis.usda.gov/*
i-Tree Tools for Assessing and Managing Community Forests *www.itreetools.org/*
Forestry Images: Forest Health, Natural Resources, and Silviculture Images *http://www.forestryimages.org/*

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