2. Insect and Disease Management

Insects, mites, fungi, bacteria, nematodes and viruses are all examples of pests found on plants. In nature, most pest populations are kept in check by predators, pathogens, competing organisms or the natural resistance of a healthy host plant. When other factors such as stress enter the system, pests may become economically damaging.

In production systems, pests have an even greater chance of becoming damaging. Crops are often produced in a monoculture system, allowing pests to move more easily from host to host. As well, some production practices can be quite stressful. For example, container-grown plants have high root-zone temperatures in the summer that can result in root mortality. A reduction in roots will decrease plant health and resistance to pest invasion. Successful growers look for early signs of plant stress and manage that stress to help prevent pest problems.

Integrated Pest Management

Integrated pest management (IPM) is an approach to pest management that utilizes all available tools to reduce pest populations to an acceptable level in a cost-effective, environmentally rational manner. These tools include monitoring, cultural control, physical control, biological control and chemical control. IPM involves accurately identifying a pest, understanding its biology and most susceptible life stage, establishing action thresholds, choosing appropriate management techniques and evaluating their effectiveness. Today, nursery growers are adopting a more integrated approach to pest management that allows them to decrease their use of chemical pesticides by making more informed decisions. Landscape professionals and arborists in Ontario must operate under the *Pesticides Act* as amended by the *Cosmetic Pesticides Ban Act, 2008.* The requirements are detailed in Ontario Regulation 63/09.

When making decisions about pest management, one must determine the level of a pest population that can be tolerated. These levels (called *action thresholds*) depend on many factors. Because the diversity of ornamental plants and plant pests is so great, data for specific pest action thresholds is often unavailable. By keeping good records, growers and landscape maintenance professionals can develop their own action thresholds. Action thresholds may be measured by the number of pests present, the percentage of plant parts showing symptoms or the level of pest injury that can be sustained before the economic loss from that injury is equal to the cost of controlling the pests (the *economic injury level*). Most healthy ornamental plants can tolerate moderate levels of pests, but landscape clients and retail garden centre customers may have lower tolerances.

Monitoring

Monitoring is the most important aspect of IPM. Monitoring data provides the basis for making informed decisions about pest management practices. Monitoring programs consist of regular physical examinations of all production areas during the growing season, including winter propagation. Most monitoring activities for pests are carried out on a weekly basis.

Early detection is the key to preventing pests from reaching levels of economic injury and may help minimize the use of pesticides.

Crop Scouts

Crop scouts monitor plant health and report observations to help direct the pest management program. Crop scouts should:

- sample plants regularly from each production block and look closely under branches, in branch crotches, on leaf undersides and on the newest emerging leaves for any unusual symptoms
- examine the crown and root systems regularly to monitor for diseases, insects and physiological problems
- communicate with growers and irrigation staff regularly to discuss plant production practices and how they might impact crop quality and pest management programs

See Table 2–1, *Host Symptoms and Possible Causes of Insect Injury*, on page 38 and Table 2–2, *Symptoms and Possible Causes of Insect Injury (by Visible Insect Matter)*, on page 38 for more information.

Crop scouts need a basic understanding of crop health. This includes some background in crop production, plant pathology, entomology and weed science. Since a wide array of woody and herbaceous ornamentals are grown in Ontario, label blocks of plants clearly (include cultivar names and planting date) and mapped them for reference. In the case of landscape properties, a basic map with plant names is an excellent reference for monitoring. Correctly identifying the host is often critical to correctly identifying the pest.

With a wide array of crop species comes an extensive group of organisms (insects, mites and micro-organisms) that may be encountered during crop production. Not all these organisms are plant pests; many are incidentals and just happen to be there or are feeding on other non-plant organisms. To help identify pests, the crop scout should have diagnostic references that outline identifying characteristics, host lists, biology and life cycle of the plant pests typically encountered in Ontario. This information can be used not only to identify the pest but also to target the life cycle stage in order to utilize various management methods. A hand lens (e.g., 10x to 20x) is a necessary tool for observing a pest's identifying characteristics. Diagnostic references may include ornamental woody and herbaceous reference books, government and university publications, and websites. For more information on diagnostic references, see the OMAF Nursery and Landscape webpage at www.ontario.ca/crops. The Pest Diagnostic Clinic offers pest identification services (see Appendix E, *Diagnostic Services*, on page 81).

Growing Degree Days (GDD) and Phenology Models

In the past, calendar dates were used to determine when to apply pesticides. This often led to unnecessary pesticide applications and applications that did not necessarily coincide with the susceptible developmental stage of the pest. Today, pest management techniques include models based on temperature, weather data and plant-pest phenology (development). The underlying principle is basic: plants and insects need a certain amount of heat to pass through the various stages of development. The temperature data is often expressed as growing degree days (GDD). To calculate these, collect maximum and minimum temperatures over a 24-hr period. Then use the formula below to calculate GDDs with various base temperatures (i.e., 10°C, 50°F). Add GDDs for each day to get a running total of GDD accumulations in your area. Do not subtract any negative GDD values.

Growing degree days formula:

$$\frac{\text{Daily Maximum Temperature} + \text{Daily Minimum Temperature}}{2} - \text{Base Temperature}^{*} = \text{Growing Degree Days}$$

** Base temperature is a constant.*

Sample calculation (at base 10°C):

$$\frac{17°C + 5°C}{2} - 10°C = 1\ \text{GDD}\ (10°C)$$

Growing degree day figures are meant to enhance the effectiveness of a monitoring program, not replace it.

Growers and landscapers use GDD models to help predict when different pests will emerge based on

temperature data they have collected themselves or obtained from the local weather office. The GDD pest models can be used to fine-tune the monitoring program and anticipate pests early. Over time, recorded temperature data for plants and plant pests have revealed that certain plants and insects pass through developmental stages at the same time. For example, when the *Magnolia* x *soulangiana* flowers are in the pink bud stage, the overwintering spruce gall adelgid nymphs are starting to feed and are susceptible to applications of insecticides. The fruiting and flowering characteristics of certain common ornamentals in the landscape have been linked to the developmental stages of plant pests. These plants are referred to as "plant phenology indicators" (see Table 2–3, *Common Phenology Plant Indicators for Ontario*, on page 39). Some horticulturalists have found plant phenology indicators to be more accurate than GDD models.

Where plant health monitoring will be carried out in many locations (as in the case of landscape maintenance), use plant phenology indicators to direct the monitoring program. The combined use of GDD data and plant phenology indicators can give a clearer picture of the timing of pest emergence and opportunities for control. For more information, see Tables 2–4 to 2–17, starting on page 41.

For more information on timing and management methods for ornamental pests in Ontario, see the ONnurserycrops blog at www.onnurserycrops.wordpress.com.

Monitoring Tools

Many tools exist to help crop scouts monitor plant pests. Although they are collectively called "traps," many of these tools are not always effective at managing pest populations. More often, they are useful for collecting data about insect emergence and populations.

- Most *baited traps* are pheromone (mating) lures or other lures (e.g., floral lures) to attract insects. Place at least two traps per monitoring area about 1–2 weeks before adults are expected to emerge. Place traps on the windward side of the monitoring area. Try to use the same type of pheromone and brand of trap from location to location and from year to year.
- *Refuge traps* provide places for insects to hide (e.g., burlap traps for black vine weevil adults and gypsy moth larvae).
- *Sticky traps* (yellow, blue, etc.) catch adult flying insects (e.g., aphids, whiteflies, leafminer adults, thrips, leafhoppers).
- *Tape* wrapped around stems and small branches (sticky side out) will capture scale insect crawlers for monitoring purposes.
- *Tapping trays* are useful for monitoring pests such as mites, plant bugs and caterpillar droppings. They consist of a white surface fixed on a frame (or a sheet of white paper on a clipboard) that is held beneath a branch. When the branch is tapped, pests drop onto the white surface, where they are visible.
- *Pitfall traps* can be used to monitor flightless pests (such as root weevil adults and slugs). They are a cup-shaped trays placed in the ground so that the top of the tray is level with the surface of the ground.

Monitoring Data Records

Record observations in an organized and accessible system (e.g., a computer data file). This monitoring data is very useful in fine-tuning action thresholds and pest management strategies in future years. Organize monitoring data under headings such as:

- date (month/day/year)
- location (e.g., farm X, block C, south side)
- host (including cultivar or variety, stage of development)
- pest and host symptoms (including pest population, pest stage of development, percentage of plants or plant parts showing symptoms)
- GDD and/or plant phenology indicators
- action taken (e.g., pesticides, rate, area treated, cultural methods)

A sample Pest Monitoring Record Sheet can be found in Appendix G, *Pest Monitoring Record Sheet*, on page 86.

Indicator Plants

Indicator plants are ornamentals that seem to attract specific pests first. For example, *Caragana* and *Acer*

serve as indicator plants for leafhoppers. Examine these plants at the beginning of each monitoring cycle. By observing indicator plants, it is possible to detect pest problems before they reach economically damaging levels and affect the rest of the crop.

Cultural Control

Cultural control activities are plant care and best management practices that help prevent the pest from becoming a problem. They include the following examples:

- Avoid irrigating late in the day, since leaf wetness periods that extend into the night may increase disease problems. Where disease is a problem, try to irrigate enough to adequately wet the root zone but less often so the soil can dry out a little between irrigation events to encourage deeper rooting.
- Grow plant cultivars that are tolerant of diseases and insects. For example, *Betula nigra* and its cultivars are more tolerant of bronze birch borer than *Betula pendula*.
- Steam-pasteurize propagation media before reusing it.
- It is very difficult to sterilize pots and inserts. Always start the propagation phase of disease-susceptible species with new pots or trays. This will help minimize the risk of transferring disease (e.g., *Fusarium*) from organic residue on used pots.
- Select only healthy plants for cuttings and budwood to avoid introducing problems into the production system.

Physical or Mechanical Control

Physical means, such as manually removing infested plants or plant parts, can be an important part of IPM.

- Remove infested plant material or pests (including weeds) from production areas and landscapes and destroy them. Use supplemental irrigation if natural precipitation is inadequate.
- Cultivate field soils to uproot weeds and expose soil-dwelling insects to natural predators.
- Apply sticky bands on the trunks of landscape trees to trap or exclude crawling insects and breeding adults and their egg masses (e.g., adult gypsy moths).
- Use yellow sticky tape to trap flying insect pests in propagation greenhouses.
- When new plant material is received by a nursery, hold it in a quarantine area (away from production areas) and monitor it for any pests or diseases.

Biological Control

There are many natural predators and parasites that keep pest populations in check. For example, predatory mites feed on many species of pest mites. Ladybird beetles (larvae and adults) and lacewings (larvae) are common predators outdoors. They feed on soft-bodied insects such as aphids, mites and scale nymphs. Ichneumonid wasps are also common parasites. The adult females lay their eggs inside soft-bodied insects such as aphids. The wasp eggs hatch and feed on the contents of their aphid host, eventually killing the host. Many broad-spectrum insecticides used to reduce pest populations also reduce populations of natural predators. When monitoring for pest populations, look for natural predators and parasites, as they are also an important aspect of pest control that can reduce the need for chemical pesticides in some situations. When choosing a pesticide, consider those that have the least impact on natural predators and parasites.

Many biological control organisms are commercially available in Ontario. Most of the biological control products that are commercially available target insects and mites and are most successful in closed systems such as greenhouses. Some predatory insects can be effective in the field, especially where a continuous supply of pollen and nectar are available throughout the growing season. Many adult predators and parasites need the energy they obtain from flower pollen and nectar in order to reproduce. If they can't find the required food source, they will leave the area and reproduce somewhere else. Predatory mites may also reduce pest mite populations in the field over the long term. Recent studies with entomopathogenic nematodes (*Heterohabditis megidis*) have shown excellent control of root weevils in container production and about a 50% reduction of root weevil populations in the field. For more information on biological control products, see OMAF Publication 370, *Guide to Greenhouse Floriculture Production.*

Chemical Control

When all other methods of management fail or when pest populations are threatening the economic value of the plants, pesticides may be the most effective solution. The pesticide program is an important part of IPM. Choose the most appropriate product that is least toxic while still effective, keeping in mind the pest and host plants it will be used on. Make pesticide applications in accordance with monitoring observations. Apply the product to coincide with the susceptible stage of the pest (according to monitoring observations). Before using a pesticide, read the product's label and understand its relative toxicity, mode of action, persistence and proper and safe application. For more information on pesticide safety, see OMAF Publication 840, *Crop Protection Recommendations for Nursery and Landscape Plants*.

Chemical pest control products are an important tool in crop production, but they must be used carefully to minimize their impact on the environment and prevent the development of pesticide resistance. While a particular level of pesticide is lethal to most individuals within a population, some individuals may survive the pesticide application and will pass on these genes to the next generation. Over time, this can lead to widespread resistance within the population. Pests become resistant to chemical pesticides when the products are used incorrectly or too often. Make note of the chemical family of each pesticide and rotate chemical families during the application period for each target pest. (Insecticides and fungicides used to protect ornamentals are listed by product name in OMAF Publication 840, *Crop Protection Guide for Nursery and Landscape Plants*.)

Best Management Practices

Growers and landscape professionals can have a major influence on plant health by considering environment (media, soil, irrigation, temperature, hardiness zone, light, spacing, planting location, etc.) and nutrients (type, rate, delivery). Slight changes in environment and nutrient availability can have dramatic effects on plant health. In the landscape, a significant portion of pest problems are due to inappropriate site conditions (e.g., soil drainage, light exposure, competition). Before installing landscape material, consider the basic needs of the plants (hardiness zone, soil pH, sunlight requirements, soil type, water, etc.). By following practices that produce and maintain healthy plants, growers can prevent many plant pests from causing economic damage.

Implementing a biosecurity protocol will help to minimize the risk of introducing and transmitting biological hazards to, within and between production facilities. Biological hazards include plant pathogens, parasites and pests. A biosecurity protocol outlines the best management practices for effective sanitation. Ensure all employees and visitors follow the protocol. Some examples include ensuring that all visiting vehicles are parked in designated areas and that all visitors check in at the office. This policy will ensure that all visitors are aware of the facility's biosecurity protocol. Footbaths and hand/boot washing stations placed at key points throughout the facility can help reduce the introduction and spread of pests.

Best Management Practices (BMPs) are an integral part of good crop management. Every grower should have guidelines to produce and maintain plants in a responsible manner, both for the health of the plants and the health of the environment. Many BMPs focus on effective water and fertilizer use, the recycling of plastics and the responsible use of pesticides. Monitor irrigation water quality and analyze growing media/leachate to catch problems early.

Sample irrigation water from each water source in the spring, summer and fall. It is good to test at least three times per year, since water levels change throughout the seasons, influencing the concentration of harmful salts. Have the samples tested for pH, EC, bicarbonates, sodium, chloride and sulphates at an accredited lab. See Appendix C, *OMAF-Accredited Soil, Leaf and Greenhouse Media Testing Laboratories*, on page 79, for a list of accredited labs and Table 1–15, *Acceptable Ranges for Chemical Properties of Irrigation Water* on page 25 for a comparative table of chemical properties of good-quality irrigation water.

In the nursery, sample the container media every 2 weeks. Alternatively, the leachate can be sampled every 2 weeks using the Pour-Thru Procedure (or Virginia Tech Extraction Method) for nursery crops as follows:

1. Allow 30–60 minutes to let pots drain after the last irrigation.
2. Place saucers underneath the pots or place the pots inside other pots with a plastic bag in between.
3. Pour enough distilled water over the pot surface to collect about 50 mL of leachate from the pot bottom. Take leachate samples from at least five pots per block (or irrigation zone) to get a good representation of the block.
4. Submit the samples to an accredited lab.

(For more details on the Pour-Through Procedure, see www.ces.ncsu.edu/depts/hort/hil/hil-401.html.)

Compare EC and pH over time and monitor fertilizer salts (e.g., N, P, K) in the soil solution. Over time, develop a database that correlates salt levels and pH with healthy plant growth. This approach allows spikes in salt levels to be detected early. When they are, using remedial watering to leach out salts will help avoid root injury before plant damage occurs. Analysis will also reveal any drop in fertilizer salt levels, when supplemental applications may be warranted. In the field or landscape, sample soils where new plantings are planned or where plant growth seems to be below optimum. For directions on testing container media see "How to Sample and Test Container Media," page 19, and Table 1–14, *Media Nutrient Levels for Most Container Crops,* on page 21. For directions on testing field soil see "How to Sample Field Soil," on page 1, as well as Table 1–5, *Phosphorus Requirements for New and Established Field Nursery Stock* on page 6 and Table 1–6, *Potassium Requirements for New and Established Field Nursery Stock* on page 7.

For more information, see:

- ***Best Management Practices: Integrated Pest Management,* Order No. BMP09**

Insects and Mites Affecting Trees and Shrubs

Insects and mites are broadly classified according to their feeding habits and the associated damage they cause to woody plants. Classifications include defoliators, sucking insects, borers, gall makers and soil pests.

Some damage is distinctive, allowing identification of the insect that caused it without even seeing the pest at work (see Table 2–1, *Host Symptoms and Possible Causes of Insect Injury* on page 38). Other pests develop within the plant tissues, concealed from view. A hand lens (e.g., 10x–20x) can be helpful to see some tiny pests such as mites.

Defoliators

Defoliating insects eat foliar tissue. They may feed singly or in dense colonies and have diverse feeding habits. For example, some defoliators consume entire leaves, while others eat only interveinal tissue. Some skeletonize the leaf surface, leaving only the leaf veins behind, while others mine between the leaf surfaces.

Some defoliators are visible on leaves, while others hide within a web, folded leaf or portable shelter. However, all defoliators damage plants by reducing the leaf area. This interferes with photosynthesis, depriving the plant of food. It also interferes with the transportation and translocation of food within the plant. Some common types of defoliators are listed below. As well, see "A Compendium of Pests and Diseases with Recommended Practices" in OMAF Publication 840, *Crop Protection Guide for Nursery and Landscape Plants.*

Caterpillars

Caterpillars are moth and butterfly larvae. They may feed in colonies or individually. Caterpillars have three pairs of true legs on the abdomen, close to the head. They also have up to five pairs of fleshy "pro-legs" located further back along the abdomen. Loopers or "inch worms" are examples of caterpillars that have two to three pairs of fleshy pro-legs.

Leaf-Eating Beetles

Many beetles feed on leaves both as adults and as larvae. Beetles can completely devour, skeletonize or mine the leaves.

Leafminers and Casebearers

Leafminer and casebearer larvae develop within leaf tissues or in a protective case of leaf fragments and frass that they carry to cover themselves while feeding. Although the pests are often concealed, their characteristic tunnels make leafminer infestations easy to identify. The tunnels may be straight, serpentine or irregular. Leafminers can be moth, sawfly, beetle or midge larvae.

Sawflies

Sawflies feed in colonies and quickly strip foliage from their host plants. In Southern Ontario this usually occurs during June and July. The adults have two pairs of wings and often resemble small bees, ranging in colour from amber to black. The larvae of most species look similar to caterpillars, with three pairs of true legs on the abdomen (close to the head). They usually have six or more pairs of fleshy "pro-legs" located further back along the abdomen.

Sucking Insects

Sucking insects include aphids, lacebugs, leafhoppers, mealybugs, mites, scales, spittlebugs and thrips. This group of pests weakens trees and shrubs by sucking the sap. Some also inject secretions that injure or kill plant cells. Most species, though small and inconspicuous, are very troublesome pests.

Because the foliage of infested plants is not chewed or torn, these plants may suffer severe injury before symptoms appear. Signs of damage include mottling and fading leaf colour, curling and twisting leaves, wilting foliage and tender shoots, hardening flower buds and malformed flowers or leaves.

Some common types of sucking insects are listed below. As well, see "A Compendium of Pests and Diseases with Recommended Management Practices," in OMAF Publication 840, *Crop Protection Guide for Nursery and Landscape Plants*.

Aphids

Aphids (plant lice) are small, soft-bodied, pear-shaped insects that vary from green to shades of red, brown or black. Some aphids feed on the leaves, while others feed on the roots and are often associated with a woolly mass. Leaf-feeding aphids commonly cluster on new growth or on the underside of leaves. The light-coloured cast skins of nymphs often remain attached to the lower surface of a leaf, similar to leafhoppers.

Aphids secrete a sweet sticky substance called "honeydew" that attracts ants, flies and wasps. Honeydew can be a nuisance when it coats objects beneath infested plants. A black sooty mould may grow on the honeydew, making the plants unsightly. This fungus does not infect the plant host and dies as soon as the honeydew is gone.

Leafhoppers

Leafhoppers are small, wedge-shaped, active insects that run, hop or fly when disturbed. Leafhoppers are usually greenish or yellow in colour, although some are striped. They commonly injure woody hosts such as apple, caragana, elm, honeylocust, hoptree, maple and rose.

Leafhoppers feed on the undersides of leaves, causing stippling or bleaching. Small yellowish dots appear on the upper surface of the affected leaves. The light-coloured cast skins of nymphs often remain attached to the lower surface of a leaf (similar to aphids), providing a critical clue to help identify the pest problem. Be cautious: it's easy to confuse leafhopper injury with that caused by two-spotted spider mite.

One species of leafhopper common to woody nursery crops is the potato leafhopper (*Empoasca fabae*). Their feeding causes leaves to become stunted and distorted and the leaf margins to turn black. It is often misdiagnosed as extreme temperature injury or burn. Symptoms are first noticeable in early June. Maple trees (sugar, Norway) are a favourite host, but potato leafhoppers can also be found on other deciduous trees.

Mites

Mites are very tiny animals related to spiders and ticks. They are not true insects. Sometimes called "spider mites," they produce webbing between plant needles or leaves. This keeps the mites from becoming dislodged and protects them from their natural enemies.

Mites reproduce rapidly during hot, dry weather and may produce several generations a year. They attack evergreens and deciduous trees, causing speckling, bleaching or bronzing of foliage. Tiny spherical eggs or broken eggshells appear as specks or spots. In severe mite infestations, foliage may drop prematurely.

Serious mite damage happens quickly, so it is important to identify mite infestations early in the season. Most mites are not visible with the naked eye. To identify a mite infestation, use a 10x–20x hand lens. Alternatively, hold a sheet of white paper under a branch and tap the branch sharply. Some mites will drop onto the paper, where they appear as tiny specks about the size of a pencil dot as they crawl about.

Mite species commonly associated with trees are:

- European red mite (*Panonychus ulmi*) on fruit trees
- oak red mite (*Oligonychus bicolor*) on oaks
- honeylocust spider mite (*Eotetranychus multidigituli*) on honeylocust
- maple spider mite *(Oligonychus aceris)* on silver-red maple hybrids
- spruce spider mite (*Oligonychus ununguis*) on spruce, hemlock, arborvitae and juniper
- two-spotted spider mite (*Tetranychus urticae*) on elm, linden, rose and ornamental fruit trees
- rust mites (various) on elm, honeylocust, maple, oak and privet

Thrips

Thrips are very tiny, slender-bodied insects that affect the leaves and flowers of several woody and herbaceous plants. They have piercing, sucking mouthparts and often feed from the inside of a leaf, leaf bud or flower bud. Thrips damage is often not apparent until infested buds open and reveal mottled and distorted growth.

Plant Bugs

This group of insects removes plant sap using piercing, sucking mouthparts. Both adults and nymphs cause damage, often injuring young, developing shoots and leaves. Symptoms of damage include stippled leaves, deformed leaves and stunted shoots.

A new introduction to southern Ontario, the brown marmorated stink bug (*Halyomorpha halys*) is a plant bug that feeds by sucking on the developing fruit, leaves and twigs of several species of fruit and ornamental woody plants. Although it does not kill plants, it has the potential to cause significant injury to trees and shrubs in the nursery and landscape. This brown stink bug can be identified by the distinctive two white bands on its antennae, white bands on legs and the white triangles in between dark bands on the edges of the membranous wings (seen at the edge when the wings are at rest). It is also a nuisance pest because it overwinters in homes.

Scale Insects

Scale insects are tiny and immobile for most of their lives. They often blend in with the host plant and feed from the undersides of the current season's twigs and leaves, making them difficult to detect. Because they are sucking insect pests, they produce honeydew and are often associated with honeydew-foraging insects (ants, wasps) and sooty mold is often found growing on the honeydew deposits. For ease of identification, scales are divided into three groups called armoured scales, soft or unarmoured scales and mealybugs.

Armoured Scales

Armoured scales are common on trees and shrubs. The scales vary in length or diameter from 2–3 mm and secrete a hard, waxy covering over their bodies. Armoured scales may be circular, oblong or pear-shaped. Examples include oystershell scale and euonymus scale.

Soft Scales

Soft scales can be large (up to 6 mm long) and are convex in shape when mature. They are either bare or enclosed in waxy or cottony secretions. Examples include Fletcher scale and magnolia scale.

Mealybugs

Mealybugs are soft-bodied insects that are usually covered with a powdery, cottony-wax material. They range from about 5–8 mm long when full grown. Unlike other scale insects, mealybugs are mobile (albeit slow moving) throughout their entire life cycle. The most common mealybug seen on outdoor ornamentals is the taxus mealybug.

Borers

Borers are beetle and moth larvae that tunnel into the buds, shoots, bark or wood of trees and shrubs. Some species attack healthy trees but most attack trees and shrubs already weakened from another stress. The larval stage feeds from within the tree (in the bark, cambium or inner wood). Emerald ash borer (*Agrilus planipennis*) and Asian long-horned beetle (*Anoplophora glabripennis*) are two of the newest borers found in Ontario. For more information see "A Compendium of Pests and Diseases with Recommended Management Practices," in OMAF Publication 840, Crop Protection Guide for Nursery and Landscape Plants. Emerald ash borer and Asian long-horned beetle are quarantine pests. This means that movement of the insects and the infested plants or plant parts is regulated to help prevent further spread into un-infested areas. For more information, contact the closest office of the Canadian Food Inspection Agency (www.inspection.gc.ca).

It is important to prevent borer injury, since infested plants may be damaged beyond repair before the pest makes itself known. Signs of damage include dying twigs and branches; dark, discoloured or dead areas under the bark (peachtree borer); and chewed matter or sawdust under the bark (red oak clearwing moth). Sap and sawdust-like borings may cling to bark and litter the ground (linden borer, carpenterworm).

Borers also provide an entrance for disease-causing fungi. They can weaken the structure of trees, making them more susceptible to wind damage. Borers may eventually girdle and kill the tree. The most serious borers are those whose larvae feed in the cambium: the green, sap-conducting and generative tissue located just under the bark. This includes the bronze birch borer and the emerald ash borer.

Gall Makers

Galls are abnormal vegetative growths produced by a plant in response to insect irritations or substances that mimic plant growth hormones. Causes include feeding, stinging, egg-laying or toxin injection. This reaction generally benefits the pest by creating a protected feeding site within host tissue.

Aphids, mites, midges, gall wasps and some beetles and moth larvae can all produce galls. Galls vary greatly in size, colour and complexity, but each insect species produces a characteristic gall formation from plant tissue. Oak and hickory trees are the favourite hosts for several hundred different gall insects. Galls may form anywhere on a tree. They mar the appearance and shape of trees and may kill leaves and branches, although they rarely kill the tree.

Soil Pests

Pests below the soil line can seriously damage plants before making themselves known. It can be difficult to determine the extent of the pest problem or the effectiveness of treatment. Monitoring programs should include examination of crowns and roots below the soil, especially where symptoms of stress are evident. Some common types of soil pests are listed below.

Japanese Beetles

Japanese beetles (*Popillia japonica*) are a quarantine pest. This means that the movement of Japanese beetles and infested plants or soil is regulated to help prevent further spread into un-infested areas. While Japanese beetles do not kill nursery crops in Ontario, the adults are significant defoliators. It is important to control infestations and prevent new ones. Established populations exist in several provinces of Canada. Contact your local CFIA office (see Appendix D, *Other Contacts*, on page 80 for a current list, or refer to the CFIA website at www.inspection.gc.ca).

Japanese beetle larvae are C-shaped, milky-white grubs about 25 mm long. They have brown heads and three pairs of legs. A V-shaped arrangement of spines on the last abdominal segment (raster) distinguishes them from other grubs. The larvae feed on the roots of turf and nursery stock.

Managing Japanese Beetles in Nurseries

Refer to the Canadian Food Inspection Agency Directive D-96-15, *Phytosanitary requirements to prevent the spread of Japanese beetle,* Popillia japonica, in Canada and the United States (www.inspection.gc.ca). Use the following strategies to reduce injury and grub populations:

- Treat container-grown stock with CFIA-approved insecticides. See CFIA guidelines regarding the treatment of Japanese beetle to allow for shipping of nursery stock (www.inspection.gc.ca).
- Watch for emerging adult beetles. Check the OMAF Nursery-Landscape Blog (www.onnurserycrops.wordpress.com) to see if adult beetles have been reported.
- Monitor for adult Japanese beetles using pheromone traps beginning around the time *Catalpa speciosa* is beginning to bloom (around mid-June in southern Ontario). Note that traps are used for monitoring, not for control. To avoid attracting beetles to your nursery, place pheromone traps in nearby pastures, vacant fields or fencerows, well away from crops. Research shows that if fewer than 4,000 beetles are trapped at peak flight, a larval population likely has not been established (especially in clean cultivated soils).
- Scout fencerows and hedgerows once adult beetles emerge. Look for beetles feeding on leaves of indicator plants (e.g., grapevines, roses), especially in early morning or late afternoon. Skeletonized leaves are a sign of Japanese beetle injury.
- Remove wild grape and other weedy host plants from the area. Adult beetles feed on different host plants than their larvae. Discourage adult beetles from feeding in the area by removing food sources. For a list of common host plants, see OMAF Factsheet *Japanese Beetle in Nurseries and Turf.*
- Control beetles in fencerows and hedges first. If beetles are observed feeding, apply insecticides before 7 AM, when adult beetles are sluggish and slow.
- Discourage egg-laying in the nursery by eliminating suitable egg-laying sites near desirable host plants. Japanese beetles lay eggs in turf areas such as pastures and grassy, weedy areas. Almost all grasses support larval populations, while alsike clover, crown vetch, white Dutch clover and Canadian mammoth clover do not.
- Keep the ground around the plant free from vegetation. When the root ball is dug, the soil that comes with it should be free of potential host plants. Provide an extra-wide clean, cultivated area at the base of trees.
- Cultivating to a depth of 7.5 cm may destroy 25%–30% of the larvae. Cultivating is most effective in early fall and late spring.
- During droughts, Japanese beetles prefer to lay their eggs in low, wet, poorly drained areas and irrigated fields.
- Containers with soilless media are not preferred egg-laying sites. Avoid the use of field soils in container media.
- Maintain a good weed control program in the field and in the container yard.

Other White Grubs

In addition to Japanese beetle larvae, the larvae of European chafers (*Rhizotrogus majalis*) and June beetles (*Phyllophaga* sp.) make up the group of insects called "white grubs." White grubs larvae move into a distinctive "C" shape when uncovered in the soil. They have a brown head capsule, three pairs of legs and an abdomen with a uniform width. Larvae of various white grub species are very similar-looking. To identify the larva species, closely examine the tiny spines on the raster (the last segment of the body). June beetle larvae have two parallel rows of stout spines on the raster and a Y-shaped anal slit. Japanese beetle larvae have two short rows of stout spines in a distinct "V" pattern on the raster and a crescent-shaped anal opening. European chafer larvae have two nearly parallel rows of spines on the raster that diverge slightly at the hind end and a Y-shaped anal slit. Mature June beetle larvae are the largest (up to 4 cm long), followed by European chafer (1.5 cm) and Japanese beetle (1.25 cm). The adult beetles fly and may cause feeding damage on the foliage of outdoor ornamentals.

Although white grub larvae traditionally attack turf, they have been expanding their host range. In the last several years, white grub larvae have been

found feeding on the roots and crowns of woody nursery stock in the field. There have also been several cases of white grubs feeding on vegetable crops and cash crops in southwestern Ontario. Monitor for grub populations in late summer. Registered insecticides for preventive purposes are most effective when used at the beginning of adult flight periods since these products will be present in the soil when the eggs are hatching. Registered insecticides (including nematodes) for curative or rescue purposes are most effective when applied by late summer when the grubs are still small enough to be susceptible and are feeding near the surface. Some indicator species (hosts) for white grub adults include Japanese tree lilac, elm and cherry, while fir and spruce are larval hosts.

Root Weevils

Root weevils are small (up to 1 cm long), white larvae that feed on the crown and roots from under the soil, which often severely damages or kills the plant. Root weevils have a brown head capsule and no legs and are fatter in the centre of their abdomen than at their ends. The absence of legs and uneven thickness distinguishes them from white grub larvae. The two most common root weevils in Ontario are black vine weevil (*Otiorhynchus sulcatus*) and strawberry root weevil (*Otiorhynchus ovatus*). Strawberry root weevils feed on crops such as white cedar and Colorado spruce, while black vine weevils have a much larger ornamental host range. No male adult specimens have ever been observed in either of these species. Strawberry and black vine root weevils are flightless and resemble a beetle except for the fact they have a long snout. These adults crawl around and feed during the night by cutting notches into leaves. The leaf notches rarely lead to serious damage but are an indication that a weevil population is present. Inspect crowns and roots for the larvae: the most damaging weevil life stage. Weevil larvae can be found feeding on roots and crowns any time from September through May. This is the period when weevil larvae are most likely to be present.

Weevil larvae are difficult to control with chemicals since they can be found well below the soil surface and are protected by the soil. Recent studies have shown that entomopathogenic nematodes (e.g., *Heterohabditis bacteriophora*) control root weevils extremely well in container production but reduce root weevil populations in the field by only 50%. Irrigation seems to limit their effectiveness in field production soils, especially where soils are sandy. Adult weevil populations can be reduced by using registered contact insecticides applied to the foliage during the early evening. Indicator species for root weevils include *Taxus, Rhododendron, Euonymus, Thuja, Heuchera* and *Sedum*.

Plant Parasitic Nematodes

Nematodes are tiny, thread-like roundworms that feed and multiply in or on a wide range of plant roots. Necrosis (dead tissue) or localized swellings in roots may indicate possible feeding sites. Nematodes may also spread soil-borne viruses and permit the development of secondary bacterial and fungal infections. Nematodes are often more prevalent in wet, poorly drained soils (especially during the growing season following a rainy year). They are more common in low-lying areas of the field. Although populations will rise dramatically during a wet growing season, symptoms of the infestation often don't show up until the following year.

Treat potential nematode problem areas before planting, using registered products such as Basamid and Vapam. Use these materials according to the manufacturer's instructions. Manage nematode diseases by rotating crops, sterilizing the soil and using disease-free planting material. For directions on sampling for nematodes, see Appendix E, *Diagnostic Service*, on page 81.

Consult the OMAF website at www.ontario.ca/crops for detailed information about nematode problems, preplant soil fumigation and the fumigation of established crops. For more information, see "Soil Fumigants" in OMAF Publication 840, *Crop Protection Guide for Nursery and Landscape Plants.*

TABLE 2–1. Host Symptoms and Possible Causes of Insect Injury

Category	Symptom	Possible Causes
Chewed leaves and/or chewed flowers	pieces of leaf or flower missing entire leaves or flowers missing	caterpillars (moth larvae, butterfly larvae) beetle larvae or adult beetles sawfly larvae grasshoppers snails slugs
Discoloured leaves	bleached leaves bronzed leaves silvered leaves stippled leaves streaked leaves	lace bugs plant bugs spider mites leafhoppers aphids psyllids thrips
Plant part distortion	mined leaves skeletonized leaves curled/cupped leaves galls on leaves, stems, flowers, twigs twisted growing points	beetle larvae caterpillars sawflies aphids gall wasps gall flies psyllids eriophyid mites
Plant dieback	dying leaves, twigs, branches dying whole plant holes and frass wilting	twig pruners root-feeding beetle larvae boring insects scales adelgids

Soybean Cyst Nematode

The soybean cyst nematode, *Heterodera glycines*, is a concern in southwestern Ontario, especially in Kent, Perth, Elgin, Essex and Prescott and Russell counties. While most field-grown nursery stock does not host this pest, practicing good soil management can help reduce its spread.

- Do not grow nursery stock on fields recently used to produce soybeans.
- Do not use equipment in nursery fields that was used to cultivate soybean fields. Attached soil can spread the nematode cysts.
- Prevent soil erosion.
- Many weeds act as host plants to soybean cyst nematode. Good weed control will reduce populations.
- Nematicides are ineffective against this pest.

TABLE 2–2. Symptoms and Possible Causes of Insect Injury (by Visible Insect Matter)

Symptom	Possible Causes
Dark fecal spots	aphids soft scales leafhoppers mealybugs psyllids whiteflies
Honeydew Sooty mould	lacebugs greenhouse thrips some plant bugs sawfly adults
Silken mats Spittle Tents Webs	leaf rollers leaftiers spittlebugs tent caterpillars webworms
Sap flow	larvae of certain kinds of moths and beetles
Pitch tubes	bark beetles
Cast skins	aphids cicadas clearwing moth larvae lacebugs leafhoppers
Pitch mass	larvae of certain kinds of moths and beetles
Flocculence (cottony waxy material)	adelgids aphids certain scales mealybugs psyllids
Slime	slugs snails

Phenology and Growing Degree Day Tables for Monitoring

Over time, recorded temperature data for the phenological development of plants and plant pests have revealed that certain plants and insects pass through developmental stages at the same time. For example, when the *Magnolia* x *soulangiana* flowers are in the pink flower bud stage, the overwintering spruce gall adelgid nymphs are starting to feed and are susceptible (vulnerable) to pesticide applications. The fruiting and flowering characteristics of certain common ornamentals in the landscape have been linked to the developmental stages of plant pests and diseases. These plants are referred to as "plant phenology indicators" (see Table 2–3, *Common Phenology Plant Indicators for Ontario*, on this page). The plant phenology indicator species listed in this table can be used to more efficiently monitor for pests and diseases on nursery and landscape plants in Ontario. Some horticulturalists have found plant phenology indicators to be more accurate than GDD models. Use plant phenology indicators to estimate the developmental life stages of common insect pests and diseases that affect nursery and landscape plants in your monitoring program. The combined collection of GDD data and plant phenology indicators can give a clearer picture of the timing of pest emergence and opportunities for monitoring and then management.

Once you know the current developmental stages of the plant phenology indicator species in your crop production area or landscape, you can look up the corresponding common pests to scout for. Tables 2–4 to 2–17 outline phenology plant characteristics, GDD summaries and corresponding pests and diseases that can help when planning plant health monitoring schedules. The presence of a "V" in the "Stage" column indicates this pest is vulnerable to pesticides, which may include horticultural oil.

Obtain the daily maximum and minimum temperatures needed to calculate GDDs from weather stations such as Environment Canada or Weather Innovations Incorporated or obtain them from on-farm weather stations.

Many of the plant phenology and pest models that follow have been developed by horticultural expert Donald A. Orton, who wrote *Coincide: The Orton System of Pest and Disease Management*. This valuable book provides detailed information on the timing for the most vulnerable life stages of common nursery and landscape pests based on plant phenology observations from over 20 years of field research. *Coincide* is available from the Labor of Love Conservatory, Wheaton, Illinois (www.laboroflove conservatory.com).

TABLE 2–3. Common Phenology Plant Indicators for Ontario

Acer platanoides	Norway maple
Acer rubrum	red maple
Acer saccharinum	silver maple
Acer saccharum	sugar maple
Aesculus hippocastanum	horsechestnut
Aesculus parviflora	bottlebrush buckeye
Amelanchier laevis	serviceberry, shadberry
Catalpa speciosa	northern catalpa
Cercis canadensis	redbud
Cirsium arvense	Canada thistle
Cornus alternifolia	pagoda dogwood
Cornus mas	cornelian cherry dogwood
Crataegus phaenopyrum	Washington hawthorn
Daucus carota	wild carrot (Queen Anne's lace)
Gleditsia triacanthos	honeylocust
Hamamelis vernalis	spring-blooming witchhazel
Hamamelis virginiana	fall-blooming witchhazel
Hydrangea arborescens 'Grandiflora'	hills of snow hydrangea

TABLE 2–3. Common Phenology Plant Indicators for Ontario *continued*

Hydrangea paniculata 'Grandiflora'	panicle hydrangea
Kolkwitzia amabilis	beautybush
Lonicera korolkowii 'Zabelii'	zabel honeysuckle
Lonicera tatarica	tartarian honeysuckle
Magnolia x *soulangiana*	saucer magnolia
Philadelphus	mock orange
Pinus mugo	mugo pine
Prunus x *cistena*	purpleleaf sand cherry
Prunus serotina	wild black cherry
Prunus triloba	flowering almond
Ribes odoratum	golden or flowering currant
Robinia pseudoacacia	black locust
Salix caprea	pussy willow
Sambucus canadensis	American elder, elderberry
Solidago canadensis	Canada goldenrod
Sorbus aucuparia	European mountain ash
Spiraea nipponica 'Snowmound'	snowmound spiraea
Spiraea x *vanhouttei*	bridal wreath spiraea
Syringa reticulata	Japanese tree lilac
Syringa villosa	late lilac
Syringa vulgaris	common lilac
Ulmus pumila	Siberian elm
Viburnum carlesii	Koreanspice viburnum
Viburnum dentatum	arrowwood viburnum
Viburnum lantana	wayfaring tree viburnum
Viburnum opulus	European cranberrybush viburnum
Weigela florida	old-fashioned weigela
Yucca filamentosa	Adam's needle

TABLE 2–4. Monitoring for Common Insect Pests and Diseases in Late March to Early April (1–25 GDD[a] Base 10°C)

Plant Phenology Indicators

Green Leaf Bud Stage	Flower Bud	Starting Bloom	Full Bloom
Gleditsia triacanthos *Syringa vulgaris*	*Syringa vulgaris*	*Acer rubrum* *Acer saccharum* *Cornus mas* *Salix caprea*	*Acer saccharinum*

Nursery and Landscape Host Plants

Plant	Pest	Developmental Stage ***(V) indicates this pest is vulnerable to pesticides***
Apple	Eastern tent caterpillar	Overwintering egg mass on small twigs
	San Jose scale	Overwintering nymphs (V)
Cherry	Eastern tent caterpillar	Overwintering egg mass on small twigs
Crabapple	Eastern tent caterpillar	Overwintering egg mass on small twigs
Deciduous trees and shrubs	Adelgids, mealybugs, mites, scales	Look for overwintered eggs, nymphs (V) on plants that were infested last year
	Gypsy moth	Overwintering egg mass on tree trunks, other wooden objects
Elm	Elm bark beetle	Adults (V), eggs under bark
Evergreen trees and shrubs	Spruce spider mite	Overwintering eggs (V) on twigs and foliage
Hawthorn	Eastern tent caterpillar	Overwintering egg mass on small twigs
Honeylocust	Honeylocust mite	Treat overwintering adult females (V) before they lay eggs, as the *Hamamelis vernalis* and silver maple blooms but before *Cornus mas* blooms.
Maple	Gall mites and wasps	Adults (V), eggs on new leaves
Pear	San Jose scale	Overwintering nymphs (V)
Pine	European pine shoot moth	Overwintering larvae in buds and tips (V)
	Pine bark aphid	Overwintering nymphs, hatching nymphs (V)
	Pine shoot beetle	Adults (V), eggs under bark
	White pine weevil	Adults (V) in leaf litter, on terminals
Spruce	Cooley and eastern spruce gall adelgid	Overwintering nymphs next to buds becoming active
Willow	San Jose scale	Overwintering nymphs (V)

[a] *GDD = Growing degree days. For more information, see page 28.*
The presence of a "V" in the "stage" column indicates this pest is vulnerable to pesticides, which may include horticultural oil.

TABLE 2–5. Monitoring for Common Insect Pests and Diseases in Mid-April to Late April (25–55 GDD[a] Base 10°C)

Plant Phenology Indicators

Green Leaf Bud Stage	Flower Bud	Mid-Bloom	End Bloom	New Leaves
Gleditsia triacanthos *Syringa vulgaris*	*Acer platanoides* *Amelchier laevis* *Magnolia* x *soulangiana*	*Acer rubrum* *Cornus mas* *Forsythia* sp. *Magnolia stellata* *Salix caprea*	*Acer saccharinum*	*Ulmus pumila*

Nursery and Landscape Host Plants

Plant	Pest	Developmental Stage ***(V) indicates this pest is vulnerable to pesticides***
Apple, cherry, crabapple, hawthorn	Apple scab	Protect apple and crabapple leaves with fungicides as soon as buds begin to open
	Eastern tent caterpillar	Young larvae (V), small tents in twig crotche
Birch	Birch leafminer	Tiny, black sawfly adults around new leaves; use sticky traps to monitor
Cherry	Eastern tent caterpillar	Overwintering egg mass on small twigs
Crabapple	Eastern tent caterpillar	Overwintering egg mass on small twigs
Deciduous trees and shrubs	Adelgids, mealybugs, mites, scales	Look for overwintered eggs, nymphs (V) on plants that were infested last year
	Gypsy moth	Overwintering egg mass on tree trunks, other wooden objects
Elm	Elm bark beetle	Adults (V), eggs under bark
Evergreen trees and shrubs	Spruce budworm	Larvae (V)
	Spruce spider mite	Overwintering eggs (V) on twigs and foliage
Hawthorn	Eastern tent caterpillar	Overwintering egg mass on small twigs
Maple	Gall mites and wasps	Adults (V), laying eggs on new leaves

Pine	European pine shoot moth	Overwintering larvae in buds and tips (V)
	Pine bark aphid	Overwintering eggs, hatching nymphs on bark
	Pine shoot beetle	Adults, eggs under bark
	White pine weevil	Adults (V), eggs on terminals
	Zimmerman pine moth	Overwintering larvae
Spruce	Cooley and eastern spruce gall adelgid	Overwintering nymphs next to buds (V)
Viburnum	Viburnum leaf beetle	Eggs on twig undersides (visible as rows of brown bumps); prune out
Yew	Fletcher scale	Overwintering nymphs on undersides of twigs and foliage

[a] *GDD = Growing degree days. For more information, see page 28.*
The presence of a "V" in the "stage" column indicates this pest is vulnerable to pesticides, which may include horticultural oil.

TABLE 2–6. Monitoring for Common Insect Pests and Diseases in Late April to Mid-May (55–100 GDD[a] Base 10°C)

Plant Phenology Indicators

Leafing Out	Flower Bud	Early Bloom	Full Bloom
Acer saccharinum	*Aesculus hippocastanum*	*Amelanchier laevis*	*Acer platanoides*
Ulmus pumila	*Gleditsia triacanthos*	*Cercis canadensis*	*Acer saccharum*
	Spiraea x *vanhouttei*	*Cornus florida*	*Magnolia* x *soulangiana*
	Syringa vulgaris	*Viburnum carlesii*	*Prunus* x *cistena*

Nursery and Landscape Host Plants

Plant	Pest	Developmental Stage ***(V) indicates this pest is vulnerable to pesticides***
Apple	Apple scab	Protect apple and crabapple leaves with fungicides as soon as buds begin to open
	Cedar-apple, cedar-quince, cedar-hawthorn rust	Begin fungicide applications to protect rosaceous hosts (where galls on juniper are sporulating)
	Eastern tent caterpillar	Larvae (V); remove tents
Ash	Ash plant bug	Protect foliage with insecticides as ash trees are breaking bud to target susceptible newly-hatched nymphs
Basswood	White grubs	C-shaped grubs in soil around damaged roots
Beech	Gypsy moth	Egg hatch at first bloom of *Cercis canadensis*
Birch	Birch leafminer	Larvae (visible as small blotches in leaves)
Boxwood	Boxwood psyllid	Newly hatched nymphs (V) feed on new leaves

TABLE 2–6. Monitoring for Common Insect Pests and Diseases in Late April to Mid-May (55–100 GDD[a] Base 10°C) *continued*

Nursery and Landscape Host Plants

Plant	Pest	Developmental Stage ***(V) indicates this pest is vulnerable to pesticides***
Cherry	Eastern tent caterpillar	Overwintering egg mass on small twigs
	Peachtree borer	Look for sawdust at soil line as sign of active overwintering larvae just under loose bark
Crabapple	Cedar-apple, cedar-quince, cedar-hawthorn rust	Begin fungicide applications to protect rosaceous hosts (where galls on juniper are sporulating)
	Eastern tent caterpillar	Overwintering egg mass on small twigs
Deciduous trees and shrubs	Adelgids, mealybugs, mites, scales	Inspect plants that were infested last year
	Fall cankerworm	Larvae (Vulnerable to insecticides such as B.t.)
	Gypsy moth	Eggs masses beginning to hatch
Dogwood	Dogwood borer	Larvae (look for holes and fresh sawdust on trunk and large branches); destroy larvae
Eastern white cedar	Fletcher scale	Nymphs (V)
Elm	Gypsy moth	Egg hatch at first bloom of *Cercis canadensis*
Euonymus	Euonymus webworm	Larvae (look for yellow larvae and webbing on shoots) (V)
Evergreens	Spruce budworm	Larvae (V)
	Spruce spider mite	Hatching nymphs (V)
	White grubs	C-shaped grubs in soil around damaged roots
Fir	Balsam twig adelgid	Nymphs (V)
	Spruce spider mite	Hatching nymphs (V)
Hawthorn	Cedar-apple, cedar-quince, cedar-hawthorn rust	Begin fungicide applications to protect rosaceous hosts (where galls on juniper are sporulating)
	Eastern tent caterpillar	Overwintering egg mass on small twigs
Hickory	Gypsy moth	Egg hatch at first bloom of *Cercis canadensis*
Honeylocust	Honeylocust pod gall midge	Newly hatched larvae (V) start feeding on emerging foliage
Juniper	Cedar-apple, cedar-quince, cedar-hawthorn rust	Begin fungicide applications to protect rosaceous hosts (where galls on juniper are sporulating)
Lilac	Lilac borer	Larvae (look for holes and fresh sawdust on trunk and large branches); destroy larvae
	White grubs	C-shaped grubs in soil around damaged roots

Linden	Gypsy moth	Egg hatch at first bloom of *Cercis canadensis*
Maple	Gall mites and wasps	Adults, eggs on new leaves
Oak	Gypsy moth	Egg hatch at first bloom of *Cercis canadensis*
Pear	Pear trellis rust, cedar-apple, cedar-quince, cedar-hawthorn rust	Begin fungicide applications to protect rosaceous hosts (where galls on juniper are sporulating)
Pine	European pine sawfly	Larvae (look for small, green larvae on new growth) (V)
	Pine bark aphid	Newly hatched nymphs (V)
	Pine spittlebug	Look for nymphs inside spittle masses on new growth; remove by hand
	White pine weevil	Larvae in terminals; prune out
	Zimmerman pine moth	Overwintering larvae (V)
Spruce	Cooley and eastern spruce gall adelgid	Nymphs found on undersides of buds (V)
	Gypsy moth	Egg hatch at first bloom of *Cercis canadensis*
	Spruce spider mite	Hatching mites (shake branch over paper and look for reddish to brown and black mites) (V)
Viburnum	Snowball aphid	Nymphs (inspect new leaves) (V)
	Viburnum leaf beetle	Hatching larvae (inspect egg sites and leaf undersides) (V)
Yew	Fletcher scale	Nymphs (V)

[a] *GDD = Growing degree days. For more information, see page 28.*
The presence of a "V" in the "stage" column indicates this pest is vulnerable to pesticides, which may include horticultural oil.

TABLE 2–7. Monitoring for Common Insect Pests and Diseases in Mid-May to Late May (100–150 GDD[a] Base 10°C)

Plant Phenology Indicators

Early Bloom	Full Bloom	Late Bloom
Prunus serotina *Sorbus aucuparia*	*Aesculus hippocastanum* *Gleditsia triacanthos* *Lonicera korolkowii* *Ribes odoratum* *Spiraea* x *vanhouttei* *Syringa vulgaris* *Viburnum lantana*	*Amelanchier laevis* *Cercis canadensis*

TABLE 2–7. Monitoring for Common Insect Pests and Diseases in Mid-May to Late May (100–150 GDD[a] Base 10°C) *continued*

Nursery and Landscape Host Plants

Plant	Pest	Developmental Stage ***(V) indicates this pest is vulnerable to pesticides***
Apple	Cedar-apple, cedar-quince, cedar-hawthorn rust	Begin fungicide applications to protect rosaceous hosts (where galls on juniper are sporulating)
	Eastern tent caterpillar	Larvae (V); remove tents
	Gypsy moth	Larva (V) feeding on foliage
Ash	Ash plant bug	Protect foliage with insecticides as ash trees are breaking bud to target susceptible newly-hatched nymphs
Beech	Gypsy moth	Larva (V) feeding on foliage
Birch	Birch leafminer	Adults, then newly hatched larvae; look for small blotches in leaves for larvae (V)
Boxwood	Boxwood psyllid	Waxy, white nymphs (not as susceptible) on new foliage
Cherry	Cedar-apple, cedar-quince, cedar-hawthorn rust	Continue fungicide applications to protect rosaceous hosts (where galls on juniper are still sporulating)
	Eastern tent caterpillar	Larvae (V); remove tents
	Gypsy moth	Larva (V) feeding on foliage
	Peachtree borer	Look for sawdust at soil line as sign of active overwintering larvae just under loose bark
Crabapple	Cedar-apple, cedar-quince, cedar-hawthorn rust	Begin fungicide applications to protect rosaceous hosts (where galls on juniper are sporulating)
	Eastern tent caterpillar	Overwintering egg mass on small twigs
Deciduous trees	Gypsy moth	Larva (V) feeding on foliage
Eastern white cedar	Eastern tent caterpillar	Larvae (V); remove tents
Elm	Elm leafminer	Adults emerge (V)
	Gypsy moth	Larva (V) feeding on foliage
Euonymus	Euonymus webworm	Larvae (look for yellow larvae and webbing on shoots) (V)
Evergreens	Spruce spider mite	Hatching nymphs (V)
Fir	Balsam twig adelgid	Nymphs (V)
Hawthorn	Cedar-apple, cedar-quince, cedar-hawthorn rust	Begin fungicide applications to protect rosaceous hosts (where galls on juniper are sporulating)
	Eastern tent caterpillar	Overwintering egg mass on small twigs
Hickory	Eastern tent caterpillar	Larvae (V); remove tents

Juniper	Cedar-apple, cedar-quince, cedar-hawthorn rust	Begin fungicide applications to protect rosaceous hosts (where galls on juniper are sporulating)
Lilac	Gypsy moth	Larva (V) feeding on foliage
	Lilac leafminer	Larvae (look for new mines in leaves) (V)
Linden	Gypsy moth	Larva (V) feeding on foliage
Maple	Gall mites and wasps	Larvae hatching
Oak	Gypsy moth	Larva (V) feeding on foliage
Pear	Pear trellis rust, cedar-apple, cedar-quince, cedar-hawthorn rust	Begin fungicide applications to protect rosaceous hosts (where galls on juniper are sporulating)
Pine	European pine sawfly	Larvae (look for small, green larvae on new growth) (V)
	Pine needle scale	Newly hatching reddish crawlers (V)
	Pine spittlebug	Look for nymphs inside spittle masses on new growth; remove by hand
	White pine weevil	Larvae in terminals; prune out
Spruce	Gypsy moth	Larva (V) feeding on foliage, lower branches first
	Spruce spider mite	Hatching nymphs (shake branch over paper and look for tiny, slow mites) (V)
Viburnum	Snowball aphid	Nymphs on new leaves (V) (they are only vulnerable to pesticides 1–10 days after egg hatch)
	Viburnum leaf beetle	Hatching larvae (inspect egg sites and leaf undersides) (V)
Yew	Taxus mealybug	Small, whitish nymphs (V) in branch crotches

[a] *GDD = Growing degree days. For more information, see page 28.*
The presence of a "V" in the "stage" column indicates this pest is vulnerable to pesticides, which may include horticultural oil.

TABLE 2–8. Monitoring for Common Insect Pests and Diseases in Late May to Early June (150–200 GDD[a] Base 10°C)

Plant Phenology Indicators

Early Bloom	Full Bloom	Candling (15–20 cm)	Late Bloom	Ripe Seed	Dropping Seed
Cornus alternifolia *Prunus serotina* *Viburnum opulus*	*Aesculus hippocastanum* *Lonicera korolkowii* *Prunus serotina* *Sorbus aucuparia* *Spirea* x *vanhouttei* *Syringa vulgaris*	*Pinus mugo*	*Aesculus hippocastanum* *Gleditsia triacanthos* *Lonicera korolkowii* *Ribes odoratum* *Viburnum lantana*	*Ulmus pumila*	*Acer saccharinum*

Nursery and Landscape Host Plants

Plant	Pest	Developmental Stage ***(V) indicates this pest is vulnerable to pesticides***
Apple	Cedar-apple, cedar-quince, cedar-hawthorn rust	Continue fungicide applications to protect rosaceous hosts (where galls on juniper are still sporulating)
	Eastern tent caterpillar	Larvae (V); remove tents
Ash	Oystershell scale	Crawlers (V)
Birch	Birch leafminer	Larvae (V) (look for small blotches in leaves)
	Bronze birch borer	Adults laying eggs (V)
Boxwood	Boxwood psyllid	Waxy, white nymphs
Cherry	Eastern tent caterpillar	Larvae (V); remove tents
Crabapple	Eastern tent caterpillar	Larvae (V); remove tents
	Cedar-apple, cedar-quince, cedar-hawthorn rust	Continue fungicide applications to protect rosaceous hosts (where galls on juniper are still sporulating)
Deciduous trees	Fall cankerworm	Larvae (V)
	Gypsy moth	Larvae (V)
	Oystershell scale	Crawlers (V)
Eastern white cedar	Cedar leafminer	Small, greyish-white adult moths (visible when foliage is disturbed) (V)
Euonymus	Euonymus webworm	Larvae (look for yellow larvae and webbing on shoots) (V)
Evergreens	Spruce spider mite	Nymphs and adults (V)

Hawthorn	Eastern tent caterpillar	Larvae (V); remove tents
	Cedar-apple, cedar-quince, cedar-hawthorn rust	Continue fungicide applications to protect rosaceous hosts (where galls on juniper are still sporulating)
Holly	Holly leafminer	Small, grey, adult flies (V); use sticky traps to trap
Honeylocust	Honeylocust plant bug	Nymphs and adults (look for tiny, green plant bugs; adults have wings) (V)
Juniper	Cedar-apple, cedar-quince, cedar-hawthorn rust	Continue fungicide applications to protect rosaceous hosts (where galls on juniper are still sporulating)
Lilac	Lilac borer	Adult flight (as lilacs begin to bloom), mating and egg-laying; treat trunk and large branches with registered pesticides
	Lilac leafminer	Larvae (look for new mines in leaves) (V)
Maple	Gall mites and wasps	Larvae inside leaf galls
Pear	Pear trellis rust, cedar-apple, cedar-quince, cedar-hawthorn rust	Continue fungicide applications to protect rosaceous hosts (where galls on juniper are still sporulating)
Pine	European pine sawfly	Small, green larvae on new growth (V) when the *Aesculus carnea* starts to bloom
	Pine needle scale	Reddish crawlers (V)
	Pine spittlebug	Look for nymphs inside spittle masses on new growth and remove by hand
	White pine weevil	Larvae in terminals; prune out
Spruce	Spruce gall adelgid	Egg hatch
	Spruce spider mite	Hatching nymphs (shake branch over paper and look for tiny, slow mites) (V)
	Yellow headed spruce sawfly	Eggs, young larvae (V)
Viburnum	Viburnum leaf beetle	Larvae feeding on leaf undersides
Willow	Imported willow leaf beetle	Adult emergence
Yew	Taxus mealybug	Small, whitish nymphs (V) in branch crotches

[a] *GDD = Growing degree days. For more information, see page 28.*
The presence of a "V" in the "stage" column indicates this pest is vulnerable to pesticides, which may include horticultural oil.

TABLE 2–9. Monitoring for Common Insect Pests and Diseases in Early June to Mid-June (200–250 GDD[a] Base 10°C)

Plant Phenology Indicators

Early Bloom	Full Bloom	Candling (15–20 cm)	Late Bloom	Ripe Seed	Dropping Seed
Spiraea nipponica *Viburnum dentatum* *Weigela florida*	*Aesculus hippocastanum* *Cornus alternifolia* *Lonicera korolkowii* *Prunus serotina* *Robinia pseudoacacia* *Sorbus aucuparia* *Spirea* x *vanhouttei* *Syringa vulgaris* *Viburnum opulus*	*Pinus mugo*	*Aesculus hippocastanum* *Gleditsia triacanthos* *Lonicera korolkowii* *Ribes odoratum* *Viburnum lantana*	*Ulmus pumila*	*Acer saccharinum*

Nursery and Landscape Host Plants

Plant	Pest	Developmental Stage ***(V) indicates this pest is vulnerable to pesticides***
Apple	Eastern tent caterpillar	Larvae (V); remove tents
Ash	Emerald ash borer	Adults emerge and are active around foliage exposed to direct sunlight
	Oystershell scale	Crawlers (V) just starting to hatch
Birch	Birch leafminer	Larvae (examine second flush of leaves for small blotches) (vulnerable to systemic insecticides)
	Bronze birch borer	Adults; finish bark applications before eggs are laid
Boxwood	Boxwood psyllid	Waxy, white nymphs on new foliage
Cherry	Eastern tent caterpillar	Larvae (V); remove tents
Crabapple	Eastern tent caterpillar	Larvae (V); remove tents
Deciduous trees	Gypsy moth	Larvae (V)
	Oystershell scale	Crawlers (V) just starting to hatch
Eastern white cedar	Cedar leafminer	Small, greyish-white adult moths (visible when foliage is disturbed) (V)
	Strawberry root weevil	Adult weevils that feed on new shoots, girdling them at the base
Elm	Elm leaf beetle	Larvae that cause holes and skeletonize foliage (V)
Euonymus	Euonymus scale	Crawlers hatch (V)

Evergreens	Spruce spider mite	Nymphs and adults (V)
Hawthorn	Eastern tent caterpillar	Larvae (V); remove tents
Holly	Holly leafminer	Small, grey, adult flies (V); use sticky traps to trap
Honeylocust	Honeylocust plant bug	Adults (look for tiny, green bugs with wings) (V)
Larch	Larch casebearer	Adults (look for tiny moths with dark wings that are easily disturbed)
Lilac	Lilac borer	Adult flight, mating and egg-laying; treat trunk and large branches with registered pesticides (V)
	Lilac leafminer	Larvae (look for new mines in leaves) (V)
Maple	Gall mites and wasps	Larvae inside leaf galls
Mountain ash	Mountain ash sawfly	Groups of yellow-green larvae (V)
Pine	Pine needle scale	Tiny, red crawlers (V)
	White pine weevil	Larvae in terminals; prune out
Roses and other ornamentals	Two-spotted spider mite	Tiny mites on the undersides of leaves (feeding causes yellow spots) (V)
Spruce	Spruce spider mite	Hatching nymphs (shake branch over paper and look for tiny, slow-moving mites) (V)
	Yellow headed spruce sawfly	Young larvae (V)
Viburnum	Viburnum leaf beetle	Larvae feeding on leaf undersides
Yew	Black vine weevil	Early emergence of overwintering adults (V)
	Taxus mealybug	Small, whitish nymphs (V) in branch crotches

[a] *GDD = Growing degree days. For more information, see page 28.*
The presence of a "V" in the "stage" column indicates this pest is vulnerable to pesticides, which may include horticultural oil.

TABLE 2–10. Monitoring for Common Insect Pests and Diseases in Mid-June (250–300 GDD[a] Base 10°C)

Plant Phenology Indicators

Early Bloom	Full Bloom	Late Bloom	Ripe Seed	Dropping Seed
Kolkwitzia amabalis *Philadelphus*	*Cornus alternifolia* *Robinia pseudoacacia* *Spiraea nipponica* *Viburnum dentatum* *Viburnum opulus* *Weigela florida*	*Aesculus hippocastanum* *Lonicera korolkowii* *Prunus serotina* *Sorbus aucuparia* *Spirea* x *vanhouttei* *Syringa vulgaris*	*Ulmus pumila*	*Acer saccharinum*

Nursery and Landscape Host Plants

Plant	Pest	Developmental Stage ***(V) indicates this pest is vulnerable to pesticides***
Apple	Eastern tent caterpillar	Larvae (V); remove tents
Ash	Emerald ash borer	Adults emerge and are active around foliage exposed to direct sunlight
	Oystershell scale	Crawlers (V) very active
Birch	Birch leafminer	Larvae (examine second flush of leaves for small blotches in leaves) (V)
	Bronze birch borer	Finish bark applications before eggs are laid
Boxwood	Boxwood psyllid	Waxy, white nymphs on new foliage
Cherry	Eastern tent caterpillar	Larvae (V); remove tents
	Peach tree borer	Newly hatched larvae (V) move to bark; apply insecticides
Crabapple	Eastern tent caterpillar	Larvae (V); remove tents
Deciduous trees	Gypsy moth	Larvae (V)
	Oystershell scale	Crawlers (V) very active
Eastern white cedar	Cedar leafminer	Small, greyish-white adult moths (visible when foliage is disturbed) (V)
	Strawberry root weevil	Adult weevils that feed on new shoots, girdling them at the base
Elm	Elm leaf beetle	Larvae that cause holes and skeletonize foliage (V)
Euonymus	Euonymus scale	Tiny, orange crawlers on twigs and leaf undersides (V)
Evergreens	Spruce spider mite	Nymphs and adults (V)
Hawthorn	Eastern tent caterpillar	Larvae (V); remove tents
Holly	Holly leafminer	Small, grey, adult flies (V); use sticky traps to trap
Larch	Larch casebearer	Adults (look for tiny moths with dark wings that are easily disturbed)

Lilac	Lilac borer	Adult flight, mating and egg-laying; treat trunk and large branches with registered pesticides (V)
Mountain ash	Mountain ash sawfly	Groups of yellow-green larvae (V)
Pine	Pine needle scale	Tiny, red crawlers (V)
Roses and other ornamentals	Two-spotted spider mite	Tiny mites on the undersides of leaves (feeding causes yellow spots) (V)
Spruce	Spruce spider mite	Hatching nymphs (shake branch over paper and look for tiny, slow-moving mites) (V)
	Yellow headed spruce sawfly	Larvae (V)
Viburnum	Viburnum leaf beetle	Larvae feeding on leaf undersides
Yew	Black vine weevil	Early emergence of overwintering adults (V)
	Taxus mealybug	Small, whitish nymphs (V) in branch crotches

[a] *GDD = Growing degree days. For more information, see page 28.*
The presence of a "V" in the "stage" column indicates this pest is vulnerable to pesticides, which may include horticultural oil.

TABLE 2–11. Monitoring for Common Insect Pests and Diseases in Mid-June to Late June (300–400 GDD[a] Base 10°C)

Plant Phenology Indicators

Early Bloom	Full Bloom	Late Bloom
Catalpa speciosa	*Catalpa speciosa*	*Aesculus hippocastanum*
Syringa reticulata	*Kolkwitzia amabalis*	*Cornus alternifolia*
Syringa villosa	*Philadelphus*	*Kolkwitzia amabalis*
	Syringa reticulata	*Robinia pseudoacacia*
	Viburnum dentatum	*Spiraea nipponica*
		Viburnum opulus

Nursery and Landscape Host Plants

Plant	Pest	Developmental Stage ***(V) indicates this pest is vulnerable to pesticides***
Ash	Oystershell scale	Crawlers (V)
Birch	Bronze birch borer	Larvae hatching and boring into bark
Cherry	Peach tree borer	Young larvae may still be susceptible to bark applications of insecticides
Deciduous trees	Oystershell scale	Crawlers (V)
Eastern white cedar	Bagworm	Newly hatched larvae with cases on foliage (V)
	Cedar leafminer	Small, greyish-white adult moths (visible when foliage is disturbed) (V)
	Strawberry root weevil	Adult weevils that feed on new shoots, girdling them at the base

TABLE 2–11. Monitoring for Common Insect Pests and Diseases in Mid-June to Late June (300–400 GDD[a] Base 10°C) *continued*

Nursery and Landscape Host Plants

Plant	Pest	Developmental Stage ***(V) indicates this pest is vulnerable to pesticides***
Elm	Elm leaf beetle	Larvae that cause holes and skeletonize foliage (V)
Euonymus	Euonymus scale	Tiny, orange crawlers on twigs and leaf undersides (V)
Evergreens	Spruce spider mite	Nymphs and adults (V)
Fir	White grubs	Japanese beetle pupae, European chafer and June beetle eggs (V) in soil
Japanese tree lilac	White grubs	Japanese beetle adults (V) and Japanese beetle pupae, European chafer and June beetle eggs (V) in soil
Juniper	Bagworm	Newly hatched larvae inside cases (V) on foliage
	Juniper scale	Tiny, yellow nymphs (V)
Larch	Larch casebearer	Adults (look for tiny moths with dark wings that are easily disturbed)
Maple	Potato leafhopper	Monitor *Caragana* and *Acer* as indicator plants; treat with insecticides at first sign of leafhopper (V)
Mountain ash	Mountain ash sawfly	Groups of yellow-green larvae (V)
Roses and other ornamentals	Two-spotted spider mite	Tiny mites on the undersides of leaves (feeding causes yellow spots) (V)
Spruce	Bagworm	Newly hatched larvae inside cases on foliage (V)
	Spruce spider mite	Hatching nymphs (shake branch over paper and look for tiny, slow-moving mites) (V)
	White grubs	Japanese beetle pupae, European chafer and June beetle eggs (V) in soil
Viburnum	Viburnum crown borer	Newly hatched larvae (V) susceptible to bark applications of insecticides
Yew	Black vine weevil	Early emergence of overwintering adults (V)

[a] *GDD = Growing degree days. For more information, see page 28.*
The presence of a "V" in the "stage" column indicates this pest is vulnerable to pesticides, which may include horticultural oil.

TABLE 2–12. Monitoring for Common Insect Pests and Diseases in Late June to Early July (400–500 GDD[a] Base 10°C)

Plant Phenology Indicators

Early Bloom	Full Bloom	Late Bloom	Fruiting
Cirsium arvense *Hydrangea arborescens* 'Grandiflora' *Sambucus canadensis*	*Catalpa speciosa*	*Philadelphus* *Syringa reticulata* *Weigela florida*	*Amelanchier laevis* *Lonicera tartarica*

Nursery and Landscape Host Plants

Plant	Pest	Developmental Stage ***(V) indicates this pest is vulnerable to pesticides***
Apple	San Jose scale	Newly hatched crawlers (V), repeat applications 7–10 days later
Cherry	Peach tree borer	Adults
Deciduous trees	Green peach aphid	Look for honeydew, sooty mould and tiny green aphids (V)
Eastern white cedar	Strawberry root weevil	Adult weevils that feed on new shoots, girdling them at the base
Euonymus	Euonymus scale	Second-generation of eggs start to hatch into crawlers (V)
Fir	White grubs	Japanese beetle pupae and adults, European chafer and June beetle eggs (V) in soil
Honeylocust	Honeylocust mite	Shake leaves over white paper and look for tiny, reddish-brown mites (V)
Japanese tree lilac	White grubs	Japanese beetle pupae and adults (V), European chafer and June beetle eggs (V) in soil
Juniper	Juniper scale	Tiny, yellow nymphs (V)
Maple	Cottony maple scale	Crawlers hatching (V)
	Potato leafhopper	Monitor *Caragana* and *Acer* as indicator plants; treat with insecticides at first sign of leafhopper (V)
Mountain ash	Mountain ash sawfly	Groups of yellow-green larvae (V)
Pear	San Jose scale	Newly hatched crawlers (V), repeat applications 7–10 days later
Pine	Redheaded pine sawfly	Small, yellow larvae on old needles (V)
	White grubs	Japanese beetle, European chafer and June beetle eggs (V) in soil
Roses and other ornamentals	Two-spotted spider mite	Tiny mites on the undersides of leaves (feeding causes yellow spots) (V)
Spruce	White grubs	Japanese beetle, European chafer and June beetle eggs (V) in soil
Willow	San Jose scale	Newly hatched crawlers (V), repeat applications 7–10 days later
Yew	Black vine weevil	Early emergence of new-progeny adults (V)

[a] *GDD = Growing degree days. For more information, see page 28.*
The presence of a "V" in the "stage" column indicates this pest is vulnerable to pesticides, which may include horticultural oil.

TABLE 2–13. Monitoring for Common Insect Pests and Diseases in Early July to Mid-July (500–700 GDD[a] Base 10°C)

Plant Phenology Indicators

Early Bloom	Full Bloom	Late Bloom	Fruiting
Cichorium intybus *Daucus carota*	*Cirsium arvense* *Daucus carota* *Hydrangea arborescens* 'Grandiflora' *Sambucus canadensis* *Yucca filamentosa*	*Catalpa speciosa* *Hydrangea arborescens* 'Grandiflora' *Yucca filamentosa*	*Lonicera tartarica*

Nursery and Landscape Host Plants

Plant	Pest	Developmental Stage
Ash	European fruit lecanium scale	Crawlers (V); repeat applications will be necessary
Deciduous trees	Green peach aphid	Look for honeydew, sooty mould and tiny green aphids (V)
Eastern white cedar	Fletcher scale	Crawlers (V); repeat applications will be necessary
	Strawberry root weevil	Adult weevils that feed on new shoots, girdling them at the base
Elm	European elm scale	Crawlers (V)
	Japanese beetle	Adult beetles emerge and are active on foliage (V)
English oak	European fruit lecanium scale	Crawlers (V); repeat applications will be necessary
Euonymus	Euonymus scale	Egg-laying, egg hatch (second generation) (V)
Fir	White grubs	Japanese beetle, European chafer and June beetle eggs (V) in soil
Grape vine	Japanese beetle	Adult beetles emerge and are active on foliage (V)
Honeylocust	Honeylocust mite	Shake leaves over white paper and look for tiny, reddish-brown mites (V)
Japanese tree lilac	White grubs	Japanese beetle adults (V) and Japanese beetle, European chafer and June beetle eggs (V) in soil
Juniper	Juniper scale	Tiny, yellow nymphs (V)
Maple	Cottony maple scale	Crawlers on leaves and twigs (V)
	Potato leafhopper	Monitor *Caragana* and *Acer* as indicator plants; treat with insecticides at first sign of leafhopper (V)
Mountain ash	Mountain ash sawfly	Groups of yellow-green larvae (V)
Pine	Redheaded pine sawfly	Small, yellow larvae on old needles (V)
	White grubs	Japanese beetle, European chafer and June beetle eggs (V) in soil

Roses and other ornamentals	Japanese beetle	Adult beetles emerge and are active on foliage (V)
	Two-spotted spider mite	Adult mites emerge (V), tiny spider mites on the undersides of leaves (feeding causes yellow spots on foliage)
Spruce	Spruce bud scale	Crawlers (V)
	White grubs	Japanese beetle, European chafer and June beetle eggs (V) in soil
Yew	Black vine weevil	Early emergence of new-progeny adults (V)
	Fletcher scale	Crawlers (V)

[a] *GDD = Growing degree days. For more information, see page 28.*
The presence of a "V" in the "stage" column indicates this pest is vulnerable to pesticides, which may include horticultural oil.

TABLE 2–14. Monitoring for Common Insect Pests and Diseases in Mid-July to Late July (700–900 GDD[a] Base 10°C)

Plant Phenology Indicators

Early Bloom	Full Bloom	Late Bloom	Fruiting	Yellow Fruit	Ripe Seed	White Flowers Turning Green
Cichorium intybus *Daucus carota* *Hibiscus syriacus*	*Daucus carota*	*Daucus carota*	*Viburnum lantana*	*Sorbus aucuparia*	*Cirsium arvense*	*Hydrangea arborescens* 'Grandiflora'

Nursery and Landscape Host Plants

Plant	Pest	Developmental Stage ***(V) indicates this pest is vulnerable to pesticides***
Ash	Fall webworm	Yellow, fuzzy larvae inside webs at ends of branches; manually remove
Deciduous trees	Green peach aphid	Look for honeydew, sooty mould and tiny green aphids (V)
Eastern white cedar	Strawberry root weevil	Adult weevils feed on new shoots, girdling them at the base
Euonymus	Euonymus scale	Second-generation crawlers (V)
Grape vine	Japanese beetle	Adult beetles that skeletonize foliage (V)
Honeylocust	Honeylocust mite	Shake leaves over white paper and look for tiny, reddish-brown mites (V)
Pine	Pine needle scale	Second-generation crawlers (V)
	Redheaded pine sawfly	Small, yellow larvae on old needles (V)
Roses and other ornamentals	Japanese beetle	Adult beetles that skeletonize foliage (V)
	Leafhoppers	Monitor *Caragana* and *Acer* as indicator plants; treat with insecticides at first sign (V)
	Two-spotted spider mite	Tiny mites on the undersides of leaves (feeding causes yellow spots) (V)
Yew	Black vine weevil	Early emergence of new-progeny adults (V)

[a] *GDD = Growing degree days. For more information, see page 28.*
The presence of a "V" in the "stage" column indicates this pest is vulnerable to pesticides, which may include horticultural oil.

TABLE 2–15. Monitoring for Common Insect Pests and Diseases in Early August to Late August (900–1,100 GDD[a] Base 10°C)

Plant Phenology Indicators

Early Bloom	Full Bloom	Late Bloom	Fruiting	Orange Fruit
Solidago canadensis	*Hibiscus syriacus* *Hydrangea paniculata* 'Grandiflora' *Solidago canadensis*	*Hydrangea paniculata* 'Grandiflora'	*Viburnum lantana* *Viburnum opulus*	*Sorbus aucuparia*

Nursery and Landscape Host Plants

Plant	Pest	Developmental Stage ***(V) indicates this pest is vulnerable to pesticides***
Ash	Fall webworm	Yellow, fuzzy larvae (V) inside webs at ends of branches; manually remove or apply B.t. when larvae are small
Birch	Fall webworm	Yellow, fuzzy larvae (V) inside webs at ends of branches; manually remove or apply B.t. when larvae are small
Cherry	Fall webworm	Yellow, fuzzy larvae (V) inside webs at ends of branches; manually remove or apply B.t. when larvae are small
	Peach tree borer	Larvae under bark
Deciduous trees	Green peach aphid	Look for honeydew, sooty mould and tiny green aphids (V)
Eastern white cedar	Strawberry root weevil	Adult weevils that feed on new shoots, girdling them at the base
Euonymus	Euonymus scale	Second generation of crawlers (V)
Grape vine	Japanese beetle	Adult beetles that skeletonize foliage
Honeylocust	Honeylocust mite	Shake leaves over white paper and look for tiny, reddish-brown mites (V)
Magnolia	Magnolia scale	Egg hatch just beginning
Roses and other ornamentals	Japanese beetle	Adult beetles that skeletonize foliage
	Two-spotted spider mite	Tiny mites on the undersides of leaves (feeding causes yellow spots) (V)
Walnut	Fall webworm	Yellow, fuzzy larvae (V) inside webs at ends of branches; manually remove or apply B.t. when larvae are small
Yew	Black vine weevil	Early emergence of new-progeny adults (V)

[a] *GDD = Growing degree days. For more information, see page 28.*
The presence of a "V" in the "stage" column indicates this pest is vulnerable to pesticides, which may include horticultural oil.

TABLE 2–16. Monitoring for Common Insect Pests and Diseases in Late August to Mid-September (1,100–1,300 GDD[a] Base 10°C)

Plant phenology indicators

Early Bloom	Full Bloom	White Flowers Turning Pink	Late Bloom	Orange Fruit
—	—	*Hydrangea paniculata* 'Grandiflora'	*Solidago canadensis*	*Sorbus aucuparia*

— *No plant phenology indicator species in these developmental stages*

Nursery and Landscape Host Plants

Plant	Pest	Developmental Stage *(V) indicates this pest is vulnerable to pesticides*
Ash	Fall webworm	Yellow, fuzzy larvae inside webs at ends of branches; manually remove
Deciduous trees	Green peach aphi	Look for honeydew, sooty mould and tiny green aphids (V)
Euonymus	Euonymus scale	Second generation of crawlers (V)
Grape vine	Japanese beetle	Adult beetles that skeletonize foliage
Honeylocust	Honeylocust mite	Shake leaves over white paper and look for tiny, reddish-brown mites (V)
Magnolia	Magnolia scale	Crawlers (V)
Roses and other ornamentals	Japanese beetle	Adult beetles that skeletonize foliage
	Two-spotted spider mite	Tiny mites on the undersides of leaves (feeding causes yellow spots) (V)

[a] *GDD = Growing degree days. For more information, see page 28.*

The presence of a "V" in the "stage" column indicates this pest is vulnerable to pesticides, which may include horticultural oil.

TABLE 2–17. Monitoring for Common Insect Pests and Diseases in Mid-September to Late October (1,300–1,700 GDD[a] Base 10°C)

Plant Phenology Indicators

Early Bloom	Full Bloom	Late Bloom	Fruiting	Ripe Seed	Fall Foliage Colour
Hamamelis virginiana *Solidago* sp.	*Hamamelis virginiana* *Solidago* sp.	*Solidago canadensis*	*Viburnum dentatum*	*Daucus carota*	*Acer saccharum*

Nursery and Landscape Host Plants

Plant	Pest	Developmental Stage ***(V) indicates this pest is vulnerable to pesticides***
Apple	Eastern tent caterpillar	Shiny, grey egg mass bands on small twigs; prune out
Ash	Fall webworm	Yellow, fuzzy larvae inside webs at ends of branches; manually remove
Cherry	Eastern tent caterpillar	Shiny, grey egg mass bands on small twigs (prune out)
	Peach tree borer	Larvae; examine cankered regions and remove infested plants
Crabapple	Eastern tent caterpillar	Shiny, grey egg mass bands on small twigs (prune out)
Evergreens	Spruce spider mite	Shake branches over white paper and look for tiny, slow-moving mites (V)
Hawthorn	Eastern tent caterpillar	Shiny, grey egg mass bands on small twigs (prune out)
Honeylocust	Honeylocust mite	Shake leaves over white paper and look for tiny, reddish-brown mites (V)
Pine	Zimmerman pine moth	Larvae (V)
Spruce	Cooley and eastern spruce gall adelgid	Tiny, grey, fuzzy nymphs next to buds (vulnerable when the *Acer saccharum* are in fall colour)
	Spruce spider mite	Shake branches over white paper and look for tiny, slow-moving mites (V)
Woody ornamentals	Overwintering insects and mites	Overwintering scales, mites, mealybugs and adelgids; flag affected plants for dormant oil application

[a] *GDD = Growing degree days. For more information, see page 28.*
The presence of a "V" in the "stage" column indicates this pest is vulnerable to pesticides, which may include horticultural oil.

Diseases Affecting Trees and Shrubs

Diseases are broadly classified according to the types of damage they cause to woody plants. Categories include foliar diseases, crown and root rots, cankers, vascular wilts, viruses and abiotic diseases.

Diseases can be caused by many factors such as bacteria, fungi, moulds, viruses and environmental conditions. Some common nursery and landscape plant diseases are listed below. As well, see "A Compendium of Pests and Diseases with Recommended Management Practices" in OMAF Publication 840, *Crop Protection Guide for Nursery and Landscape Plants*.

Foliar Diseases

Most disease symptoms appear first on plant foliage. However, damaged foliage may not necessarily mean there is a leaf disease. Leaves may wilt, turn yellow or brown, spot, drop off or deform due to diseases not directly associated with the leaves. For example, plant foliage can change in response to vascular wilts, root diseases or cankers elsewhere on the plant. Non-infectious agents such as drought, wet soil (overwatering) and air pollution can also cause disease-like symptoms on the foliage. Quite often root problems aren't detected until foliar symptoms begin to appear. Before diagnosing any plant problem, always check that the roots are white and firm, not brown and mushy.

Most foliar diseases develop in response to high humidity and extended periods of leaf wetness. Schedule irrigation so that crops that are sensitive to foliar diseases are only watered in the early to mid-morning, never late in the day or at night. This will ensure the shortest possible periods of leaf wetness and minimize foliar diseases.

Downy mildew, powdery mildew, leaf spots, anthracnose and needlecast are common diseases that infect foliage directly. Rust diseases that cause leaf spots on broadleaf hosts are also discussed under "Cankers" on page 63 (due to their symptoms on the alternate host).

Botrytis (Grey Mould)

This disease, caused by the fungus *Botrytis cinerea*, can affect succulent tissue of bulbs, stems, leaves and flowers. It often attacks open or fading flowers and leaves, succulent soft growth and damaged tissue. Symptoms vary from host to host. In very humid air, botrytis causes a fuzzy grey growth on infected plant parts.

High humidity promotes botrytis outbreaks. Reduce humidity by providing good air circulation around plants. Remove all fading, senescing and diseased plant parts promptly, especially when wet weather is predicted. Avoid overhead irrigation late in the day, and never leave old leaves or flowers on plants or on the surrounding soil surface.

Downy Mildew

Downy mildew appears early in the season. Under very high humidity, it can produce grey to brown downy growth (sporulation) on the undersides of leaves. Once the humidity drops (by mid-morning, for example), the downy growth will disappear. Discoloured, purplish, angular spots may appear on the upper surface of the leaves.

Warm or cool wet weather and poor air circulation promote downy mildew. Reduce humidity by providing good air circulation around plants. Remove all fading, senescing and diseased plant parts promptly, especially when wet weather is predicted. Avoid overhead irrigation late in the day, and never leave old leaves or flowers on plants or on the surrounding soil surface.

Powdery Mildew

Several species of fungi cause powdery mildew. Powdery mildews produce powdery white mats on upper leaf surfaces and young tissue. Wind-borne spores can cause secondary infections, although individual powdery mildew species do not spread readily from one kind of plant to another.

Powdery mildew usually appears after the mid-season, when warm days follow cooler nights. It affects many woody ornamentals, such as *Syringa, Rosa, Ligustrum* and *Amelanchier*, and several herbaceous perennials. Because the fungus grows mainly on the plant surface, it can be managed with

fungicides at the first sign of symptoms. In some cases, as with roses, severe deformation may result.

On some ornamental plants (e.g., *Physocarpus*) powdery mildew can appear as exceptionally thick and wooly. On others (e.g., *Coreopsis, Sedum, Berberis*) powdery mildew appears as a variable leaf spot and the characteristic white mycelium and spores may not be visible. On these plants, it is often misdiagnosed.

To reduce powdery mildew, place plants in a sunny location with good air circulation. Where possible, use resistant or tolerant plant cultivars. Overhead watering during the day may reduce the spread and development of powdery mildew. Avoid overhead irrigation late in the day, as this will promote spore development at night.

Leaf Spot and Anthracnose

"Anthracnose" refers to several plant diseases that cause dead spots on leaves or fruits. This disease may also affect the twigs, causing a canker and dieback. Infected areas may coalesce into large necrotic spots as the disease spreads. In severe cases, this condition defoliates the plant. Leaf spotting itself is not harmful. However, extensive annual defoliation year after year can lead to plant decline and death.

Cool, wet, cloudy spring weather promotes infection by fungi that cause leaf spot and anthracnose. *Catalpa, Populus, Juglans, Carya, Crataegus, Acer, Quercus, Platanus, Philadelphus, Sorbus* and *Aesculus* are common hosts. Sycamore anthracnose (*Gnomonia plantani*) can be severe in Ontario and has been linked to the death of many trees in the eastern United States.

Needlecast

Needlecast diseases are fungi affecting pines (*Pinus*), spruce (*Picea*) and firs (*Abies*). New needles generally become infected just after the new growth starts. Tiny black fruiting bodies may develop along the infected needles, often in place of the tiny white stomates. Needles infected the previous season are "cast" (i.e., fall off) during the following summer and fall. Needlecast can be serious in 1–4-year-old plants at Ontario tree nurseries.

Apple Scab

Although "scab" describes a fungal disease on fruit, this disease also causes purplish blotches on leaves of *Malus*.

Apple scab (*Venturia inaequalis*) can lead to the defoliation of crabapples when cool, wet weather occurs in mid-to-late spring, during leaf emergence. Minimize apple scab through cultural practices. Plant the trees in open, sunny areas with good air movement and maintain tree health. Prune the trees regularly to encourage air circulation through the canopy. Since the disease overwinters on fallen leaves, collect these leaves in the late summer and remove them from the area. This practice may prove ineffective if other diseased trees are growing nearby. If leaf removal is not possible, try using a mower to mulch leaves as they drop throughout the autumn season. The smaller leaf sections will accelerate bacterial breakdown, resulting in fewer fungal fruiting bodies to produce infective spores the following spring.

Where possible, plant scab-resistant crabapple cultivars. If cool, wet weather persists during leaf emergence or scab symptoms begin to appear, apply registered fungicides. Apply the first spray when the green leaf tips appear. Repeat every 7–10 days until leaves harden off.

Pyracantha Scab

Pyracantha scab *(Venturia pyracanthae*) destroys the fruit of susceptible firethorn varieties. Spraying is necessary most years. The cultivars 'Orange Glow,' 'Orange Charmer' and 'Mohave' have some resistance to this disease.

Crown and Root Rots

Soil fungi such as *Pythium* and *Phytophthora* cause the roots and crowns of many plants to rot. These fungi are most often associated with overwatering or poor soil drainage. The lower leaf parts, petioles and stems of diseased plants develop a water-soaked appearance. Eventually, the plant rots off at ground level. For ornamentals, protectant fungicides (such as Subdue MAXX) can be incorporated into the media at time of potting to reduce *Pythium* and *Phytophthora* diseases.

Rhizoctonia and *Fusarium* fungi cause a brown cankering of plant stems and roots below ground. *Thielaviopsis* causes severe root rot in infected plants. Tissues affected by a *Thielaviopsis* infection are more black than brown, helping to distinguish it from other infections. When this condition affects seedlings, the disease is called "damping-off." *Thielaviopsis* is more common in floriculture crops than in nursery crops.

The Canadian Food Inspection Agency (CFIA) regulates the importation of SOD host nursery stock in Canada. These regulations can be found on the CFIA website in Directive D-01-01, *Phytosanitary Requirements to Prevent the Entry of* Phytophthora ramorum. The list of plant genera regulated for *Phytophthora ramorum* can be found in Appendix 1 of this directive.

For the most up-to-date information on Sudden Oak Death, contact your local Canadian Food Inspection Agency office (see Appendix D, *Other Contacts,* on page 80) or consult the CFIA website at www.inspection.gc.ca. Another excellent reference is www.suddenoakdeath.org.

The Canadian Nursery Industry has its own domestic phytosanitary certification program (Clean Plants) to limit the spread of this and other pests. For more information, see "Nursery Programs" at www.canadanursery.com.

Cankers

Cankers kill bark and cambial tissues in localized branch and stem areas. Bark in affected areas may discolour, split or be easily removed, exposing the wood below. Subsequently, the underlying cambium and wood are killed and will turn brown or reddish brown to black. Fruiting "pustules" of the disease organism usually form on the areas of dead bark. Cankers may girdle a stem or branch, killing portions of the plant.

Canker diseases can be annual or perennial. They commonly damage hosts weakened by factors such as drought, marginal hardiness, root disturbance or a poor root environment. Weak parasitic fungi (species of *Cytospora, Nectria, Valsa* and *Hypoxylon*) cause damaging canker diseases that a healthy, vigorous host would resist by compartmentalizing (sealing off the fungus inside callus tissue). While fungi may be the main cause of some canker growth, the original tissue damage may be due to sunscald, freeze-thaw or mechanical injury.

Some canker diseases (e.g., white pine blister rust, chestnut blight and butternut canker) can be very serious to forest health. "Monoculture" growing systems used in plantations and forest nurseries may provide conditions for serious canker diseases.

Boxwood blight (*Cylindrocladium buxi*) is a serious canker disease of boxwood. Boxwood blight causes small, discontinuous, black, rod-shaped cankers along the lower stems and branches. This fungus kills precious cambial tissue under the bark. Boxwood blight also causes a leaf blight, but it is the cankers that are a better diagnostic sign of this disease.

Sudden oak death (SOD) is a disease caused by the pathogen *Phytophthora ramorum,* a fungus-like organism that thrives in cool, wet conditions. This is a serious disease that has been associated with the death of hundreds of thousands of oak trees in California since it was first detected in the 1990s. It is also responsible for the death of many trees in several European countries. Since its detection, SOD disease surveys have shown that this organism can infect and spread on over 65 genera of plants, many of which are grown as ornamental plants. Ornamental plants are traded widely between

countries, and nursery stock has been identified as a major pathway of unnatural spread for SOD. Because of this, SOD-host nursery stock is regulated throughout parts of the world. In North America, this includes several counties of California and one in Oregon. Of the many host plants, six high-risk genera have been associated with the spread of SOD via nursery stock: *Camellia, Rhododendron, Viburnum, Pieris, Kalmia* and *Syringa.*

Chemical control for canker diseases is not always effective. Thoroughly prune diseased branches well below the affected areas. Remove and destroy infected material. For long-term management, improve host health and vigour using cultural means.

Rust

Rust diseases involve fungi that cause reddish-brown (rusty) spots on leaves, twigs or stems or gelatinous orange structures on evergreens. They frequently distort the shape of infected plant parts. Some rusts have only one host plant, but most require two hosts, each at a different phase of their life cycle. While both hosts are necessary for the disease organism to thrive, one host plant may be severely damaged while the other suffers little or no damage.

Bacterial Blights

Fire blight, a bacterial disease caused by *Erwinia amylovora*, affects many members of the *Rosaceae* family including *Amelanchier, Aronia, Chaenomeles, Cotoneaster, Crataegus, Malus, Photinia, Prunus, Pyracantha, Pyrus, Sorbus* and *Spiraea*. Flowers, spurs, twigs and leaves turn brown and dry out. Dead leaves remain on the plant and appear scorched. In warm, humid weather, an amber material may be exuded from recently infected parts. Bleeding perennial cankers may appear on limbs, trunks or roots as the infection spreads. Fire blight infections can be severe if conditions are warm and wet when the host trees are blooming and leaves are emerging. Rain, wind and insects can spread this disease from plant to plant. Manage fire blight by pruning cankers 0.3 m below the affected area when the trees are dormant and by removing nearby infection sources, such as neglected apple or pear trees. Always disinfect pruning instruments after each pruning cut. Bactericidal sprays at flowering may be helpful. For more information, see OMAF Publication 360, *Guide to Fruit Production.*

Bacterial blight (*Pseudomonas syringae* pv. *syringae*) has been linked to dieback on container nursery stock. Many deciduous, woody shrubs including lilacs (*Syringa*), mock orange (*Philadelphus*) and ornamental cherry (*Prunus)* are susceptible to this bacteria. Symptoms first appear when container stock is uncovered in the spring, revealing blackened shoots and buds that have been killed. Extreme changes in temperature coupled with extended periods of leaf wetness seem to encourage the development of bacterial blight in container production. Some growers have reduced disease incidence by installing drip irrigation systems to keep foliage dry and delaying the removal of poly cover over high-value, susceptible stock. To help reduce disease pressure, apply bactericides after leaves drop in the autumn and then again as the buds begin to swell and break during spring.

Other bacteria cause leaf spots on foliage. *Pseudomonas* and *Xanthomonas* species of bacteria infect foliar tissue during hot, humid weather and often show up in July during exceptionally hot summers. They cause angular leaf spots on several species of deciduous flowering shrubs such as *Hydrangea*. The margins of the leaf spots are usually delineated by minor leaf veins, creating a pattern similar to an aerial view of fields and roads. Bactericidal applications may be used to protect the disease from spreading to other foliage. However, pesticides will not cure existing infections.

Crown Gall

The bacterium *Agrobacterium tumefaciens* causes rough, irregular galls up to several centimeters in size. Crown gall can affect most woody plants, including rosaceous hosts, euonymus, willow and nut trees. It occurs mainly near the soil line at the root collar but also on roots and aerial parts such as top-grafted willow stems. While not a true canker disease, crown gall is included in this section because it disrupts the plant's vascular system, resulting in girdling.

This bacterium can live in the soil without host plants for about 2 years. It enters the plant through wounds such as those caused by cultivation, pruning or grafting. To limit the incidence of crown gall on susceptible top-grafted standards (e.g., *Salix*), grow the plants in polyhouses where they are sheltered from wind that could blow soil particles and bacteria onto wounds. Use sanitary propagation practices such as sterilizing grafting tools after each cut. Remove or replace infested soils, or leave them fallow for 2 years before replanting. Chemical controls are not always effective.

Vascular Wilts

Fungi or bacteria entering a plant's vascular system can reduce the amount of water that reaches the leaves, causing wilt. In the early stages of wilt, leaves may recover temporarily during cool, moist periods. Eventually, the wilt becomes established and the leaves and twigs die, leading to branch mortality and the eventual death of the entire plant. Serious vascular wilt diseases include Dutch elm disease (*Ceratocystis ulmi*) and Verticillium wilt (*Verticillium dahliae*).

To avoid wilt diseases, use resistant plant cultivars and grow susceptible crops in disease-free soil. See Table 2–18, *Woody Plants Resistant to Verticillium Wilt* on this page, and Table 2–19, *Woody Plants Susceptible to Verticillium Wilt* on page 66. Sometimes it is possible to maintain plants infected with Verticillium wilt by improving vigour through pruning, fertilizing and watering. Since these disease organisms live in the plant, surface application of fungicides will not be effective. *Verticillium* is a soil-borne fungus that persists in the soil for many years. Verticillium wilt has been associated with field-grown trees where root systems were repeatedly wounded by cultivation or pruning. When considering a field for the production of *Verticillium*-susceptible trees, test soil for *Verticillium* populations first.

TABLE 2–18. Woody Plants Resistant to Verticillium Wilt

All monocots (grass-like) plants	
All conifers	
The following broadleaf plants:	
Betula	birch
Carya	hickory
Celtis	hackberry
Cercidiphyllum	katsura tree
Chaenomeles	flowering quince
Cornus	dogwood
Crataegus	hawthorn
Fagus	beech
Gleditsia	honeylocust
Ilex	holly
Juglans	butternut, walnut
Liquidambar	sweetgum
Malus	apple, crabapple
Morus	mulberry
Platanus	plane tree, sycamore

TABLE 2–18. Woody Plants Resistant to Verticillium Wilt *continued*

All monocots (grass-like) plants	
All conifers	
The following broadleaf plants:	
Populus	poplar
Pyracantha	firethorn
Pyrus	pear
Quercus	oak
Rhododendron	rhododendron
Salix	willow
Sorbus	mountain ash
Tilia	linden
Zelkova	Japanese zelkova

TABLE 2–19. Woody Plants Susceptible to Verticillium Wilt

Acer	maple
Aesculus	buckeye, horsechestnut
Amelanchier	serviceberry
Buxus	boxwood
Calluna	heath
Catalpa	catalpa
Cercis	red bud
Cladrastus	yellowwood
Cotinus	smokebush
Daphne	daphne
Eleagnus	Russian olive
Fraxinus	ash
Gymnocladus	Kentucky coffee tree
Hibiscus	hibiscus
Koelreuteria	golden rain tree
Ligustrum	privet
Liriodendron	tulip tree
Lonicera	honeysuckle
Magnolia	magnolia
Phellodendron	cork tree
Prunus	cherry and other stone fruit
Rhododendron	azalea
Rhus	sumac
Ribes	currant, gooseberry
Robinia	black locust
Rosa	rose
Sambucus	elder
Spiraea	spirea
Syringa	lilac
Ulmus	elm
Viburnum	viburnum
Vitis	grape vine
Wiegela	wiegela

Viral Diseases

Viral diseases appear on plants as mottled yellow foliage, misshapen or wrinkled leaves, aborted flowers or stunted growth. There are no pesticides effective against viruses. Remove diseased plants and destroy them to prevent the virus from spreading to the rest of the block.

Most viral diseases spread via insects and infected tools such as pruning equipment, knives and shears. To reduce the spread of viral diseases, reduce the levels of sucking insects such as aphids, thrips, leafhoppers and mites. Disinfect all tools and implements before using them again. Samples of symptomatic plants can be sent to the Pest Diagnostic Clinic (see Appendix E, *Diagnostic Service*, on page 81) to analyze for virus particles. Destroy infested plants where possible to prevent further spread to other susceptible crops.

Ash Yellows

Plants show reduced growth, stunting and smaller leaves. Symptoms can vary with the age of the plant. In some cases, plants develop chlorotic leaves and witches' brooms (a proliferation of shoots at the tips of branches).

Elm Yellows

Leafhoppers probably transmit these mycoplasma-like organisms. Leaves of infected trees begin to turn yellow, twist and droop (epinasty) by mid-summer. The infected leaves often drop, and the branch dies shortly after.

Rose Mosaic

Rose mosaic symptoms can include leaf discolouration, chlorotic mottling, ring spots, light green or chlorotic line patterns, vein clearing, banding and white or yellow mosaics. Specific symptoms vary with the cultivar, the environment and the strain of virus.

Abiotic Diseases

Abiotic diseases principally affect foliage and/or root system function. They are usually related to extreme environment (too hot, too dry, too wet, etc.). These diseases cause many plant problems, often predisposing affected plants to attack by secondary disease organisms. The result can be gradual dieback and death.

Weather, soil conditions and human environmental disturbances cause these conditions. Control measures depend on eliminating or avoiding damaging factors (e.g., salt injury), obtaining resistant plants and improving growing conditions. Sudden exposure to full sunlight after a cloudy, wet period can cause late-spring leaf scorch in *Acer* and *Fagus*.

Root scorch created by high salt levels in the soil is a common abiotic condition. It is the result of salty groundwater or run-off containing road salt. It can only be alleviated by increasing soil aeration and leaching the soil with low-salt water.

The ability of a plant to accommodate environmental change varies with the type of plant, its age and condition, and the nature and intensity of the changes. Oak, maple, ash and spruce have difficulty adjusting to new conditions such as soil compaction, drought, excessive water (causing reduced aeration in the root zone), changes in soil level or root damage during construction. Exotic species such as Norway spruce may not be as well adapted to the Ontario climate as native species.

Dieback

Nursery and landscape ornamentals often exhibit dieback of leaves and small branches. Symptoms may appear on individual branches or entire plants. Dieback may appear suddenly or develop so gradually that the true impact does not show for several years.

Some of the environmental and cultural causes of dieback include girdling wires, strings and ropes left on after transplanting. Root problems, soil conditions, waterlogging, changes in soil grade, sunscald and freeze-thaw temperatures may also be at fault.

Light-to-moderate infestations of insects and diseases can also cause dieback symptoms. Some examples include scale insects, wood-boring insects, bark-boring insects, root-feeding weevils, white grub larvae, cankers, rusts, fire blight and vascular wilts.

Fall Needle Drop in Conifers

As shorter, cooler autumn days approach, older needles (2–3 whorls back) towards the inside of many conifers begin to turn yellow or brown. In some cases, these needles start to drop. Although this is usually a natural process, the degree of discolouration and leaf drop may relate to stress during the growing season. Low vigour caused by drought, transplanting, poor drainage, soil compaction, insects and disease make needle drop worse. Pines lose their oldest needles (closest to the trunk). White pines (*Pinus strobus*) often lose needles that are 2 years old or older. Branchlets of Eastern white cedar (*Thuja occidentalis*) often turn brown on the inside of the branches and fall off. Fir (*Abies*) and spruce (*Picea*) may lose needles on 1–3-year-old wood.

Needle Desiccation on Conifers

Winter desiccation may cause conifer needles to turn brown and drop in the spring. Many factors can lead to this condition, especially dry, windy weather while the soil is frozen. Roots cannot absorb enough water from the frozen soil to compensate for the foliar desiccation caused by winter winds. Warm afternoon temperatures in late winter can also contribute to foliar water loss.

Good growing conditions during the previous growing season help plants resist winter damage. Roots in the upper soil surface are sensitive to drying and high temperatures. If these roots die during the growing season, they may not be able to store enough water to recover from moisture losses during the winter.

Salt Damage

Woody plants are affected by road salt, both from run-off into the soil and airborne spray created by traffic. Salty run-off from sidewalks and roadways can accumulate in the soil around the root system and lead to physiological drought in the plant. When plant tissues are wet and temperatures are above freezing, sodium and chloride ions (the most common ingredients in road salt) enter plant tissues and accumulate. Repeated road salt injury weakens plants, making them susceptible to damage from many insects and diseases.

Salt spray causes more plant damage than run-off. It can affect plants located 100 or more metres away from a road. Symptoms appear more quickly in warm weather and are usually more severe on the side facing the road. Evergreen foliage and dormant buds can absorb salts and be killed.

Salt Damage Symptoms on Conifers

Symptoms of salt damage on conifers include:

- needle browning, beginning at the tip
- needle browning and twig dieback on the side facing the road, with little or none on the opposite side
- no needle browning or dieback on branches near the ground under continuous snow cover
- needle and twig dieback that is less severe the further the tree is from the road
- browning that appears in late February or early March and becomes more obvious through spring and summer

Salt Damage Symptoms on Deciduous Plants

Symptoms of salt damage on deciduous plants include:

- slow bud break on terminal parts of branches facing the road
- leaves that fail to emerge on terminal parts of branches facing the road
- new growth on branches facing the road that develops as multiple shoots just behind dead branch tip, causing a tufted or witches' broom appearance to branches
- flower buds facing the road side that do not open, while normal flowering occurs on plants further away from the road
- injury that becomes evident as buds begin to break

Leaf Scorch

Scorch happens when plants have difficulty taking up water, usually during hot, dry weather. Scorch appears as sudden leaf death or browning on leaf margins or between leaf veins, often in the heat of the summer. The veins frequently remain green.

Recently transplanted ornamentals are at the greatest risk because their root system is limited. Plants experiencing root injury due to construction, soil compaction, chemicals, drought or extreme heat can also show symptoms of scorch.