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Woody ornamentals
pest management in Wisconsin

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PEST MANAGEMENT AND PESTICIDES

Controlling a pest is only part of a total pest management program. Pest control is a corrective measure; you use pesticides or some other control method to reduce a damaging (or potentially damaging) pest population. Pest management, however, includes preventative measures as well.

The primary goal of your pest management program is to maintain pest damage at an acceptable level. Years ago, especially with the advent of pesticides, people thought they could eradicate pests. We know now that this is rarely possible; pest populations merely adapt to our control tactics. In fact, our attempts at eradication may create more problems than they solve (pesticide resistance, secondary pest outbreaks, etc.). Pesticides are vital, effective tools for agriculture but they can no longer be viewed as a cure-all for all of our pest problems. Rather, they must be viewed in the context of a total pest management program.

INTEGRATED PEST MANAGEMENT

Integrated Pest Management (IPM) is the coordinated use of multiple pest control methods. It encourages the use of all available techniques where practical and does not rely on a single-method approach. A sound IPM program can help us apply pesticides only when necessary.

IPM is by no means a new concept; some forms of integrated pest control have been practiced for centuries. The significance of today's IPM concept is that it is based on a scientific and systematic approach. You must be familiar with the crop, the pest, and all available control tactics to develop and implement an IPM program.

To help train growers, field scouts, and consultants, the University of Wisconsin conducts field scout training classes each year in Madison and River Falls, and a Wisconsin crop diagnosis training program at Arlington. In addition, IPM training seminars are available throughout the year for nursery crops. For more information about the Wisconsin IPM program, contact your county Extension agent or call the state IPM coordinator at 608-263-4073.

FEDERAL PESTICIDE-USE LAW

When Congress amended the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) in 1972, it included a mandate for the Environmental Protection Agency (EPA) to evaluate all new and existing pesticide products for potential harm they may cause. It also made it illegal to use, except as provided by FIFRA, any pesticide in a manner inconsistent with its labeling. Deviations from the label not recognized by FIFRA are a violation of the law.

The Food Quality Protection Act (FQPA) of 1996 strengthens the system that regulates pesticide residues on food. Recognizing that pesticide residues are present in more sources than just food, the FQPA sets limits on the total exposure from residues found in food, drinking water, and nondietary sources (such as household, landscape, and pet uses). As a result, the more uses a particular pesticide has, the greater the chance its total exposure will be met and, thus, some or all of its uses will be cancelled.

If, during the pesticide registration process, the EPA finds a product to generally cause unreasonable adverse effects on the environment, including injury to the applicator, it will be classified as restricted-use. Because restricted-use products can be used only by certified applicators, the FIFRA amendments also called for each state to develop a program for training and certifying pesticide applicators. The certification program is designed to ensure that users of restricted-use products are properly qualified to handle and apply these materials safely and efficiently. A current list of restricted-use pesticides registered for use in Wisconsin may be downloaded from the Pesticide Applicator Training web site (ipcm.wisc.edu/pat).

WISCONSIN'S TRAINING & CERTIFICATION PROGRAM

In Wisconsin, responsibility for training lies with the University of Wisconsin-Extension's Pesticide Applicator Training (PAT) program, while actual certification is the responsibility of the Wisconsin Department of Agriculture, Trade, and Consumer Protection (WDATCP). The Wisconsin Pesticide Law requires that all commercial applicators for hire participate in the training and certification process if they intend to use any pesticide in the state of Wisconsin, whether or not it is restricted-use.

Since 1977, the PAT program has trained over 181,000 Wisconsin applicators in the safe handling of pesticides. The training prepares the applicators for the written certification exam administered by the WDATCP, which enforces Wisconsin's pesticide regulations.

The selection, use, and potential risks of pesticides vary depending on the method of application and what it is you want to protect from pests. Therefore, there is a separate training manual and certification exam for 21 pest control categories, including categories for: agricultural producers, the agricultural industry (10 categories), in and around commercial and residential buildings (6 categories), in right-of-way and surface waters (3 categories), and preserving wood. Certification is valid for 5 years, after which you can recertify by passing a new exam that is based on a revised training manual.

Nearly 100 percent of 4,500 applicators surveyed said training materials helped them to use pesticides properly. Over 86 percent changed their pesticide-handling practices as a result of the training. Finally, the regulated community—including pesticide manufacturers, dealers, and applicators—strongly support training and certification as a way to protect people and the environment while ensuring that pesticides remain an option in pest management. We encourage all applicators to take advantage of the training and certification process, whether or not you use restricted-use pesticides.

If you want or need to become certified or recertified, contact your county Extension office.

WISCONSIN PESTICIDE LAWS AND REGULATIONS

Operating under the provisions of the Wisconsin Pesticide Law and Administrative Rule, Chapter ATCP 29 (Register, May 1998), the WDATCP has primary responsibility for pesticide use and control in the state. The Wisconsin Department of Natural Resources (WDNR) has responsibility for pesticide use involving "waters of the state," the control of birds and mammals, and pesticide and container disposal. Wisconsin Emergency Management (WEM) has responsibility for helping communities evaluate their preparedness for responding to accidental releases of hazardous compounds, including pesticides, under Title III of SARA. Finally, it is your personal obligation to become familiar with all pertinent laws and regulations and to adhere to them explicitly.

PESTICIDES AND COMMUNITY RIGHT-TO-KNOW

To help communities evaluate their preparedness for responding to chemical spills, Congress passed the Emergency Planning and Community Right-to-Know Act (EPCRA). This law is part of a much larger legislation called the Superfund Amendments and Reauthorization Act (SARA) and is often referred to as Title III of SARA. Title III sets forth requirements for reporting of hazardous substances stored in the community and for developing an emergency response plan. Wisconsin passed a similar law, Wisconsin SARA Law, which establishes the reporting and planning structure in our state.

The first step in emergency planning is to know which chemicals can cause health problems and environmental damage if accidentally released. The EPA prepared a list of such chemicals and called them extremely hazardous substances. These substances are subject to emergency planning and the threshold planning quantity, the smallest amount of a substance which must be reported. Some of the chemicals listed are commonly used in agricultural production (see table 1).

Table 1. Examples of agricultural chemicals subject to Title III of SARA

Active ingredient	Trade name	Threshold planning quantity (lb or gal of product)
azinphos-methyl	Guthion 35WP	28.5 lb
dimethoate	Dimethoate 4EC	125 gal
endosulfan	Thiodan 50W	20 lb
paraquat	Gramoxone Max	3.3 gal

A complete list of EPA's extremely hazardous substances is available from the Local Emergency Planning Committee in your county or from the EPA web site: www.epa.gov/oem/content/epcra/epcra_plan302c.htm.

Any facility, including farms, that produces, uses, or stores any of these substances in a quantity at or greater than their threshold planning quantity must notify WEM and their Local Emergency Planning Committee (LEPC) that it is subject to the emergency planning notification requirements of Title III of SARA. Notification must include the name and location of the facility, kinds and amounts of extremely hazardous substances stored, and name of a contact person.

In addition to emergency planning notification, agricultural service businesses with one or more employees are subject to two community right-to-know reporting requirements: submission of material safety data sheets (MSDS) and submission of Tier II inventory forms. Tier II forms request specific information on each hazardous chemical stored at or above its threshold.

WORKER PROTECTION STANDARD (WPS) FOR AGRICULTURAL PESTICIDES

The federal Worker Protection Standard (WPS) for Agricultural Pesticides took effect January 1, 1995. Its purpose is to reduce the risk of employee exposure to pesticides. You are subject to the WPS if you have at least one employee who is involved in the production of agricultural plants in a nursery, greenhouse, forest, or farming operation.

The WPS requires employers to do the following:

- Display pesticide safety information in a central location.
- Train uncertified workers and handlers on general pesticide safety principles.
- Provide personal protective clothing and equipment to employees.
- Provide a decontamination site (water, soap, towels, and coveralls).
- Provide transportation to an emergency medical facility for employees who are poisoned or injured by pesticide exposure.
- Provide notification to employees about pesticide applications (see below).

For more information about the WPS and the training requirements for uncertified workers and handlers, download the 2005 edition of the EPA's *How To Comply* manual from www.epa.gov/agriculture/htc.html.

ORAL NOTIFICATION AND POSTING

The WPS requires employers to give notice of pesticide applications to all workers who will be in a treated area or walk within 1/4 mile of a treated area during the pesticide application or during the restricted entry interval (described below). Notification may either be oral warnings or posting of warning signs at entrances to treated sites; both are necessary if the label requires dual (oral and posting) notification. A current list of dual-notice pesticides registered for use in Wisconsin may be downloaded from ipcm.wisc.edu/pat.

Wisconsin's ATCP 29 posting rule is designed to protect the general public as well as workers. Thus, it requires posting of areas treated with pesticides having a dual notification statement or, for nonagricultural pesticide applications, if the label prescribes a restricted entry interval for that particular application. Refer to On-Farm Posting of Pesticide-Treated Sites in Wisconsin for a flow chart guiding users through a series of questions to determine when posting of treated sites is needed, what warning sign to use, and where the sign should be located. It also covers the separate posting requirements for chemigation treatments. This publication is available from your county Extension office or online at ipcm.wisc.edu/pat.

RESTRICTED ENTRY INTERVAL (REI)

A restricted entry interval (REI) is the length of time that must expire after pesticide application before people can safely enter the treated site without using personal protective equipment. Pesticide residues on a treated crop or in a treated area may pose a significant hazard to workers or others who enter the area after treatment. Therefore, nearly all pesticides affected by the WPS (see above) have an REI (see tables 4, 8, and 10). Check the Agricultural Use Requirements section on the label for the specific restricted entry interval for your product. These intervals must be strictly observed.

PESTICIDE TOXICITY

There are four common ways in which pesticides enter the human body—through the skin (dermal), the mouth (oral), the lungs (inhalation), and the eyes. Absorption through the skin is the most common route of poisoning of agricultural workers.

Perhaps the greatest hazard for the applicator is in loading and mixing the pesticide concentrate, which presents a significant risk of exposure to the chemical in its most toxic form. Although hazards associated with the actual application are frequently much less severe, they can still be substantial, especially if there is significant drift or if appropriate precautions are ignored. A pesticide may be toxic as a result of exposure to a single dose (acute toxicity) or as a result of repeated exposures over time (chronic toxicity).

Acute toxicities are normally expressed as the amount of pesticide required to kill 50% of a population of test animals (usually rats or rabbits). For oral and dermal exposure, this is referred to as the LD_{50} or "lethal dose to 50%" in milligrams of toxicant per kilogram of body weight (mg/kg). For inhalation exposure, it is expressed as the LC_{50} or "lethal concentration to 50%" in parts per million (ppm) of toxicant in the total volume of air when the toxicant is a gas or vapor, and in milligrams per liter (mg/l) of air or water when the toxicant is a dust or mist. Pesticides with greater acute toxicities have lower LD_{50} and/or LC_{50} values; that is, it takes less of the chemical to kill 50% of the test population.

Labels indicate the relative level of acute toxicity through the use of signal words and symbols that are established by law and reflect general categories of toxicity (see table 2). The toxicity category is assigned on the basis of the highest measured toxicity, be it oral, dermal, or inhalation; effects on the eyes and external injury to the skin are also considered.

Table 2. Toxicity categories of pesticides

	Toxicity category			
Measure of toxicity	**I High toxicity**	**II Moderate toxicity**	**III Slight toxicity**	**IV Low toxicity**
Oral LD50 (mg/kg)	0–50	50–500	500–5,000	>5,000
Dermal LD50 (mg/kg)	0–200	200–2,000	2,000–20,000	>20,000
Inhalation LC50				
gas/vapor (ppm)	0–200	200–2,000	2,000–20,000	>20,000
dust/mist (mg/l)	0–0.2	0.2–2	2–20	>20
Eye effects	corrosive	irritation persists for 7 days	irritation reversible within 7 days	no irritation
Skin effects	corrosive	severe irritation	moderate irritation	mild irritation
Signal word	DANGERa	WARNING	CAUTION	CAUTION

mg/kg = milligrams per kilogram < = less than
ppm = parts per million > = greater than
mg/l = milligrams per liter
a Products assigned to Category I due to oral, inhalation, or dermal toxicity (as distinct from eye and skin local effects) also must have the word "poison" and the "skull and crossbones" symbol on the label.

HUMAN POISONING

Pesticide poisoning. ***Poisoning must be recognized early for effective treatment.*** Early symptoms are usually a headache, feeling of weakness, blurred vision, excessive perspiration, and nausea. Abdominal cramps, vomiting, and excessive salivation may set in with, or without, diarrhea. The throat and chest will feel constricted and breathing will be difficult. In mild cases of poisoning, some of these symptoms may be absent. In cases of organophosphate and carbamate poisoning, symptoms may appear and progress rapidly.

In case of human poisoning. Call a doctor at once if you suspect pesticide poisoning. Move the individual from the area of exposure. Remove contaminated clothing and wash skin with plenty of soap and water to remove all traces of the chemical. The pesticide label and MSDS contain first aid information and additional information for medical personnel. Take the victim to professional medical help immediately and take along a copy of the pesticide label, or at least the chemical and common names of the active ingredient(s) and the name and address of the manufacturer. A medical emergency phone number often is listed on the pesticide label.

Poison Control Center (1-800-222-1222). You may call the Poison Control Center at any hour for information regarding proper treatment of pesticide poisoning. While other hospitals and medical facilities may have some information, the Poison Control Center has the most complete and current files and their personnel are specifically trained to deal with poison cases.

Most labels also list a phone number that you (or medical personnel) can call for specific information on poisoning (or other accidents) involving that particular product.

PESTICIDE SAFETY

Before you handle pesticides, stop and read the label. Labels contain human safety precaution statements and list the specific personal protective clothing and equipment that you need to wear. Some of the following may be label requirements; others are commonsense guidelines that will help minimize pesticide exposure to you, your family and neighbors, and the environment.

- Wear a long-sleeved shirt, long trousers, shoes, and socks when handling pesticides.
- Wear coveralls (fabric or chemical-resistant) over your work clothes for an added layer of protection.
- Unless the label states otherwise, always wear chemical-resistant gloves whenever you work with pesticides.
- Wear chemical-resistant footwear, gloves, eyewear, and respirator (if the label requires one) when mixing, loading, or applying pesticides.
- If you wear fabric coveralls, also wear a chemical-resistant apron when mixing and loading pesticides.
- Stand in the crosswind when mixing or loading pesticides.
- Never apply pesticides when there is the likelihood of significant drift.
- Never leave a spray tank containing pesticide unattended.
- Avoid back-siphoning into the water source.
- Never eat, drink, or smoke when handling pesticides.
- Wash hands thoroughly after handling pesticides.
- If you splash pesticide on yourself, remove contaminated clothing immediately and wash yourself thoroughly.
- Wash contaminated clothes separately from other household laundry.
- Keep pesticides in original containers.
- Store and lock pesticides out of the reach of children.
- Observe restricted entry intervals on a treated crop or area.

PESTICIDE ACCIDENTS

Pesticide spills. Regardless of the magnitude of a spill, the objectives of a proper response are the same—you must control the spill, you must contain it, and you must clean it up. A thorough knowledge of appropriate procedures will allow you to minimize the potential for adverse effects.

The Wisconsin Spill Law provides specific guidelines for reporting spills to the WDNR. You do NOT need to report the spill if it is completely confined within an impervious secondary containment, and the spilled amount can be recovered with no discharge to the environment. On the other hand, a spill of any amount is reportable if it occurred outside of secondary containment and it caused, or threatens to cause, adverse effects on human health or the environment (e.g., back siphoning). The spill is exempt from the

WDNR reporting requirements if you deem the spill will not cause, or threaten to cause, such adverse effects, and the amount spilled would cover less than 1 acre if applied at labeled rates and, if a SARA pesticide, is less than the reportable quantity.

Reportable spills involving SARA substances (see "Pesticides and Community Right-to-Know," above) are to be reported to WEM, your LEPC, and the WDNR. Spills of any other compound need to be reported only to the WDNR. To simplify emergency notification requirements to state agencies, call WEM's spill hotline (1-800-943-0003, 24-hour number) whenever a spill of any compound occurs. Calling this hotline will not, however, remove your responsibility of notifying your LEPC.

Spills of some compounds may require that you notify federal authorities by calling the National Response Center (1-800-424-8802). Your call to WEM's spill hotline should provide you with assistance in determining whether federal authorities need to be notified.

Pesticide fires. In the event of a fire, call the fire department and clear all personnel from the area to a safe distance upwind from smoke and fumes. Isolate the entire area. Always inform the fire department of the nature of the pesticides involved and of any specific information that may help them in fighting the fire and protecting themselves and others from injury. For information on cleanup and decontamination, contact WEM and the pesticide manufacturer(s).

Livestock poisoning. When you suspect animal poisoning by pesticides, first call your veterinarian. If the cause of poisoning cannot be determined, call the WDATCP's Animal Toxic Response Team at 608-224-4500.

Wildlife poisoning or water contamination. Contact the WDNR district office. District offices are located in Spooner, Rhinelander, Eau Claire, Green Bay, Milwaukee, and Fitchburg.

PESTICIDE DRIFT

It is impossible to totally eliminate pesticide drift. Drift occurs because of unforeseen wind variations and other factors, many of which are beyond the applicator's control. People living in areas subject to pesticide drift worry about the acute and chronic effects of exposure to pesticides. State rules governing pesticide drift attempt to strike a balance between the intended benefits of pesticide use and the potential risks to those exposed to pesticide drift.

According to state law, people living adjacent to land that is aerially sprayed with pesticides can request to be notified at least 24 hours before application. Beekeepers also are entitled to notification of applications that occur within a 1.5-mile radius of their honeybee colonies. Both ground and aerial pesticide applications are subject to advance notification requirements to beekeepers who request such notification.

For ground applications, you can minimize drift by following these recommendations:

- Follow all label precautions for specific drift-reduction measures.
- Spray when wind speed is low.
- Use the maximum nozzle orifice without sacrificing pest control activity.
- Keep pressure at the lowest setting possible without distorting spray pattern and distribution.
- Use drift-control agents when permitted by product label.
- Consider using nozzles specifically designed to reduce drift.
- Leave an untreated border strip next to adjacent property.

For more information about drift—what it is, how it occurs, and drift management principles—ask for Managing Pesticide Drift in Wisconsin: Field Sprayers from your county Extension office. This publication also describes the critical role the pesticide applicator plays in deciding whether to spray when arriving at the site.

PESTICIDES AND GROUNDWATER

Trace amounts of pesticides are now appearing in our nation's groundwater. To minimize further contamination, many pesticide labels contain precautionary statements either advising against or prohibiting use in areas vulnerable to groundwater contamination. A summary of these precautionary statements is included under the "Remarks" heading for pesticides in this publication.

To protect our state's water resources, Wisconsin's Groundwater Law created two guidelines to limit the presence of fertilizer and pesticides in groundwater: enforcement standards are maximum chemical levels allowed in groundwater and preventive

action limits are set at a percentage of the enforcement standard. When contamination approaches preventive action limits, the responsible party must implement corrective measures to prevent further contamination.

Since 1984, several groundwater monitoring studies have been conducted in Wisconsin to determine the extent of contamination. The results of these studies indicate widespread pesticide and nitrate contamination of our groundwater resources. The most commonly found pesticide is atrazine. Consequently, Wisconsin implemented Chapter ATCP 30 to help minimize further contamination of our groundwater by atrazine. Under this rule, statewide rate restrictions have been implemented and, in some geographic areas, use of atrazine is prohibited.

Mixing and loading pesticides. Mixing and loading pesticides pose a high risk of point source contamination of ground–and surface water because of the concentration, quantity, and type of pesticides that are usually handled at a mixing and loading site. To minimize this risk of environmental contamination, Wisconsin requires that certain mixing and loading sites have secondary containment.

Both private and commercial applicators are required to have a mixing and loading pad if more than 1,500 lb of pesticide active ingredient are mixed or loaded at any one site in a calendar year, or if mixing and loading occurs within 100 feet of a well or surface water. In-field mixing is exempt from the pad requirements provided mixing or loading at the site of application occurs 100 feet or more from a well or surface water.

Agricultural Chemical Cleanup program. Cleanup of contaminated soil or of contaminated groundwater itself is costly. The Agricultural Chemical Cleanup program helps ease the financial burden for facilities and farms by reimbursing them for eligible costs associated with the cleanup of sites contaminated with pesticides or fertilizers. For more information, contact the WDATCP at 608-224-4519.

CALIBRATING PESTICIDE EQUIPMENT

Accurate and uniform pesticide application is basic to satisfactory pest control. Too often a grower does not know exactly how much pesticide has been used until the application is completed. This leads to substantial monetary losses due to unnecessary pesticide and labor costs, unsatisfactory pest control resulting in reduced yields, and crop damage. Good pesticide application begins with accurate sprayer or granular applicator calibration. One method of calibration is described in the *Training Manual for the Private Pesticide Applicator.* It also is found in the *Training Manual for the Commercial Pesticide Applicator: Turf and Landscape.* Both of these are available at www.ipcm.wisc.edu/pat.

CLEANING PESTICIDE SPRAYERS

Thorough sprayer cleaning is necessary when switching from one pesticide type to another. This is especially important when herbicides are applied with the same equipment as fungicides or insecticides. If you apply significant quantities of different types of pesticides, reserve one sprayer for herbicides only and another for insecticides and fungicides.

Follow these guidelines for cleaning spray equipment. Clean on a wash pad and apply rinsate to sites listed on label.

1. Flush the sprayer tank, lines, and booms thoroughly with clean water and apply the pesticide contaminated rinsate to sites listed on label.
2. Select the appropriate cleaning solution for the pesticide used:

   Hormone-type herbicides (e.g., 2,4-D, Banvel): Fill the sprayer with sufficient water to operate, adding 1 quart household ammonia for every 25 gallons of water. Circulate the ammonia solution through the sprayer system for 15 to 20 minutes and then discharge a small amount through the boom and nozzles. Let the solution stand for several hours, preferably overnight. (Please note: household ammonia will corrode aluminum sprayer parts.)

   Insecticides, fungicides, and other herbicides: Fill the sprayer with sufficient water to operate, adding 0.25 to 2 lb powder detergent (liquid detergent may be substituted for powder at a rate to make a sudsy solution) for every 25 to 40 gallons of water. Circulate the detergent solution through the sprayer system for 5 to 10 minutes and then discharge a small amount through the boom and nozzles. Let the solution stand for several hours, preferably overnight.

3. Flush the solution out of the spray tank and through the boom.
4. Remove the nozzles, screens, and strainers and flush the system twice with clean water.
5. Scrub all accessible parts with a stiff bristle brush.
6. Rinse the sprayer thoroughly with clean water and reassemble.

PREPARING PESTICIDE SPRAYERS FOR STORAGE

Before storing the sprayer at the end of the season:

1. Clean the sprayer per label instructions or as specified above.
2. Fill the sprayer with sufficient water to operate adding 1 to 5 gallons of lightweight emulsifiable oil, depending upon the size of the tank. Circulate the oil/water solution through the sprayer system for 5 to 10 minutes.
3. Flush the solution out of the spray tank and through the boom; the oil will leave a protective coating on the inside of the tank, pump, and plumbing.
4. Remove the nozzles, screens, and strainers and place them in diesel fuel or kerosene to prevent corrosion. Cover the nozzle openings in the boom to prevent dirt from entering.
5. As an added precaution to protect pumps, pour 1 tablespoon of radiator rust–inhibitor antifreeze in each of the inlet and outlet ports. Rotate the pump several revolutions to completely coat the interior surfaces.

PESTICIDE DISPOSAL

It is the legal responsibility of all pesticide users to properly dispose of pesticide waste. Disposal is the final act of safe and judicious pesticide use. Follow established guidelines to ensure that human health and the environment are not subject to unreasonable risks. It is illegal to bury or burn any pesticide containers in Wisconsin.

Some pesticides are considered "hazardous" by the EPA. Disposing waste or excess resulting from use of these pesticides comes under stringent regulations of the Resource Conservation Recovery Act (RCRA). This federal law and the accompanying state law (NR 600) regulate generators of hazardous waste—those who need to dispose of hazardous pesticides.

The simplest way to avoid becoming a hazardous-waste generator is to triple rinse all pesticide containers and apply rinsates to labeled sites. If you must generate hazardous waste, disposal procedures may differ depending on the volume of waste generated and its characteristics. Regardless of the volume generated, you are responsible for disposing of it in an environmentally acceptable manner.

You can reduce the amount of pesticide waste (hazardous or not) by following these steps:

- Determine whether the pesticide you intend to use is considered hazardous by the EPA. A list of these pesticides is available from your county Extension office. If listed, check for alternative pesticides that are not hazardous and will provide equivalent pest control.
- Mix only the amount of pesticide needed and calibrate equipment so all solution is applied.
- Attach a clean water supply to the sprayer unit so the tank can be rinsed and the rinsate applied to the labeled site while still in the field.
- Triple rinse all pesticide containers. Even if the pesticides were hazardous, a triple-rinsed container is not hazardous waste and you can dispose of it in a sanitary landfill.
- Don't mix hazardous waste with other pesticide waste. This will result in the entire mixture being considered hazardous.

Wisconsin Clean Sweep program. The Wisconsin Clean Sweep program offers a way to dispose of most kinds of pesticide waste including liquids, dry formulations, and hazardous pesticides. The program has two components to deal with agriculture and household pesticides. Wisconsin Clean Sweep is sponsored by WDATCP and individual counties. Check with your county Extension office or search for "clean sweep" on the WDATCP website (datcp.state.wi.us) for details on when a site will be held in your area.

Plastic pesticide container recycling program. The best way to dispose of plastic containers is to recycle them. The Wisconsin Crop Production Association (WCPA) sponsors this program and sets up collection sites throughout the state. This program accepts triple-rinsed plastic pesticide containers dropped off at designated sites. Dirty

containers will not be accepted. The containers are then transported to a granulation site where they are pelletized for recycling. Check the WCPA website (www.wicrops.org) or your county Extension office to find out when a collection site will be in your area.

Please note that this recycling program is not a Wisconsin Clean Sweep program; waste pesticides will not be accepted at container collection or granulation sites.

Recycling mini-bulk tanks. *Although mini-bulk tanks can be recycled at the same time as smaller jugs, dealers must register.* In addition to recycling small containers, Wisconsin dealers and growers also may recycle mini-bulk tanks (60 gallons and larger). Only dealers are allowed to bring tanks to the collection site, although the program will accept farmers' tanks if they are brought to the site by a dealer. There is a nominal fee and tanks must have all metal removed. Collection and recycling of mini-bulk tanks are held on odd-numbered years; please check with WCPA (608-249-4070) for details.

A FINAL WORD

Chemical pesticides can be used as part of a successful disease, insect, and weed management program. However, pesticides present hazards to agricultural workers, the general public, and the environment. Therefore, they should be used wisely, safely, and only when needed. Proper crop management can lessen the need for pesticide use, because a well-maintained planting is less susceptible to disease, insect, and weed pests.

Note: When applying a pesticide, always follow the directions on the pesticide label. Label information changes from time to time. The current pesticide label is the final authority for safety and legality.

PESTS OF WOODY ORNAMENTALS

This section lists the more common insects, diseases, and other problems associated with woody ornamentals in Wisconsin. While you won't see all of the listed pests each year for a given species, it's a good idea to familiarize yourself with the common disease and insect problems and scout regularly throughout the season for them. Routine scouting can help you detect problems before they become economically damaging and apply pesticides only when needed. This approach can help you cut production costs as well as reduce environmental and health hazards.

Table 3. Pests of woody ornamentals and scouting seasons

Host plant			Pest[a]	Scouting season
CONIFERS				
Abies (Fir)	Insects		Bagworm	mid-May to September
			Balsam gall midge	mid-May to mid-June
			Balsam twig aphid	May to early June
		x	Pales weevil	April to May, August to September
			Pine needle scale	May
			Spruce spider mite	April to May, September to October
			Tussock moth	April to May, August
	Diseases	x	Phyllosticta leaf spot	May to September
			Rhizosphaera needle & twig blight	mid-April to mid-July
		x	Root rot	all year
Juniperus (Juniper)	Insects		Bagworm	mid-May to September
		x	Fletcher scale	late June to July
			Shothole borer	June
			Spruce spider mite	April to May, September to October
			Tip dwarf mite	late April to May
	Diseases	x	Kabatina twig blight	April to May
		xx	Phomopsis twig blight	May to early July
		x	Root rot	all year
		xx	Rust	late May to mid-September
Larix (Larch)	Insects		Larch casebearer	June to August
			Larch sawfly	early June to September
			Wooly larch aphids	September

[a] x = pest is present most years but is only occasionally a serious problem; xx = pest is an annual pest problem. *(continued)*

[b] Only on Pagoda dogwood *(Cornus alternifolia)*

[c] Found in infested plant stock in Dane County in 2009. No other known incidences in the state.

Table 3. Pests of woody ornamentals and scouting seasons *(continued)*

Host plant			Pest[a]	Scouting season
CONIFERS				
Picea (Spruce)	Insects		Bagworm	mid-May to September
			Cooley spruce gall adelgid	mid-April to late May
		x	Eastern spruce gall adelgid	early April, September to mid-October
			Pine needle scale	May
		x	Spruce needle miner	mid-April to late May, late June to mid-July
		x	Spruce spider mites	April to May, September to October
			White pine weevil	March to April, mid-August to mid-September
	Diseases	x	Cytospora canker	all year
		xx	Rhizosphaera needlecast	mid-April to mid-July
		x	Rust	May to June
Pinus (Pine)	Insects	xx	Aphids	July to August
			Bagworm	mid-May to September
		x	European pine sawfly	April to May
		x	European pine shoot moth	April, mid-June to mid-July
		xx	Gypsy moth	early April to late August
		x	Pales weevil	April to May, August to September
		x	Pine bark adelgid	May to September
		x	Pine needle scale	May
		x	Pine spittlebug	late May to mid-August
		x	Red-headed pine sawfly	early June to mid-August
			Shothole borer	all year
		x	Spruce spider mite	April to May, September to October
		x	White pine aphid	May to June, September (eggs)
		x	White pine weevil	March to April, mid-August to mid-September
			Zimmerman moth	April to mid-May
	Diseases	xx	Brown spot	July through September
			Cyclaneusma needlecast	mid-April to late June
		xx	Dothistroma needle blight	July through September
		x	Late damping off and root rot	April to August
		x	Lophodermium	April through May, October
		x	Sphaeropsis	May to August
		x	White pine blister rust	July to September
	Misc.	x	Ozone sensitivity	July to August
		x	Sulphur dioxide sensitivity	July to August
Pseudotsuga (Douglas fir)	Insects	x	Cooley spruce gall adelgid	April
			Pales weevil	April to May, August to September
			Pine needle scale	May
			Spruce spider mite	April to May, September to October
			Tussock moth	June to early July
	Diseases		Swiss needle cast	April through May, August through September

[a] x = pest is present most years but is only occasionally a serious problem; xx = pest is an annual pest problem. *(continued)*

[b] Only on Pagoda dogwood *(Cornus alternifolia)*

[c] Found in infested plant stock in Dane County in 2009. No other known incidences in the state.

Table 3. Pests of woody ornamentals and scouting seasons *(continued)*

Host plant			Pest[a]	Scouting season
Taxus (Yew)	Insects	x	Black vine weevil	late May to September
		x	Fletcher scale	late June to July
			Taxus mealybug	April to May
	Misc.		Dieback	November to March
Thuja (Arborvitae)	Insects	x	Arborvitae leafminer	late May to June
		x	Fletcher scale	late June to July
			Lecanium scale	June to August
			Shothole borer	June
		x	Spruce spider mite	April to May, September to October
	Disease	xx	Phomopsis	May to early July
Tsuga (Hemlock)	Insects		Bagworm	mid-May to September
		x	Hemlock eriophyid mite	April to October
		x	Hemlock scale	June
		x	Spruce spider mite	April to May, September to October
DECIDUOUS TREES AND SHRUBS				
Acer (Maple)	Insects	xx	Aphids	April to September
		x	Cottony maple scale	July
			Erinium gall mite	July to August
		xx	Fall cankerworm	May
		x	Leafhopper	late June to September
			Lecanium scale	July
		x	Maple bladder gall mite	May to June
			Maple petiole borer	May to June
			Obliquebanded leafroller	June
			Oystershell scale	late May to June
		xx	Spring cankerworm	May
			Tussock moth	April to May, August
			Yellownecked caterpillar	August to September
	Diseases	x	Anthracnose	late May to June
		x	Bacterial wetwood (slimeflux)	all year
			Basal canker	all year
			Leaf scorch	late July to September
		x	Phyllosticta leaf spot	May to September
		x	Septoria leaf spot	July to September
		x	Tar spot	May to July
		xx	Verticillium wilt	July to September
Aesculus	Insect	x	Oystershell scale	late May to June
(Horsechestnut)	Disease	x	Leaf blotch	July to August
Amelanchier	Insect		Pear slug sawfly	late May to June
(Serviceberry)	Diseases		Cedar-hawthorn rust	June to August
		xx	Fireblight	May to June
		x	Powdery mildew	July to August
Berberis (Barberry)	Insects		Barberry inchworm	late May to September
			Lecanium scale	July
	Diseases		Anthracnose	late May to June
			Bacterial leafspot	May to June
			Verticillium wilt	July to September

[a] x = pest is present most years but is only occasionally a serious problem; xx = pest is an annual pest problem. *(continued)*

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[c] Found in infested plant stock in Dane County in 2009. No other known incidences in the state.

Table 3. Pests of woody ornamentals and scouting seasons *(continued)*

Host plant			Pest[a]	Scouting season
DECIDUOUS TREES AND SHRUBS				
Betula (Birch)	Insects	xx	Aphids	April to September
		x	Birch leaf skeletonizer	June to July
		x	Bronze birch borer	June to mid-July
		x	Dusky birch sawfly	May, mid-July to September
		xx	Fall webworm	June to August
		xx	Gypsy moth	early April to late August
		xx	Japanese beetle	late June to September
			Leafhopper	late June to September
		x	Leafminer	May to July
			Lecanium scale	July
			Tussock moth	April to May, August
			Yellownecked caterpillar	August to September
	Diseases	xx	Canker	all year
		x	Leaf rust	mid-August to October
			Leaf spot	June to September
Carya (Hickory)	Insects	xx	Aphids	April to September
		x	Fall webworm	June, August
			Lacebugs	July to August
			Walnut caterpillar	July to September
Celtis (Hackberry)	Insects	x	Hackberry nipple gall psyllid	May to September
			Lecanium scale	July
			Yellowneck caterpillar	August to September
Cercis (Redbud)	Insects		Lecanium scale	July
		x	Two-marked treehopper	June to July
Cornus (Dogwood)	Insects	x	Dogwood borer	May to early July
			Four-lined plantbug	June to July
		x	Oystershell scale	June
			San Jose scale	June, August
	Diseases	x	Anthracnose	May to June
			Botryosphaeria dieback	June to September
			Golden canker[b]	all year
			Phytophthora crown canker	May to September
		xx	Septoria leafspot	late June to September
Corylus (Hazelnut)	Insects	xx	Aphids	April to September
		x	Galls	all year
		x	Oystershell scale	June
	Diseases		Crown gall	all year
			Leafspots	June to September
Cotinus (Purpleleaf Plum)	Insects	x	Lesser peachtree borer	mid-June to early July
		x	Peachtree borer	mid-June to early July
	Diseases		Verticillium	July to September

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Table 3. Pests of woody ornamentals and scouting seasons *(continued)*

Host plant			Pest[a]	Scouting season
DECIDUOUS TREES AND SHRUBS				
Cotoneaster (Cotoneaster)	Insects		Cotoneaster webworm	May to mid-June
			Obliquebanded leafroller	June
		x	Oystershell scale	June
		x	Pear slug sawfly	late May to June
		x	San Jose scale	June, August
	Diseases		Crown gall	all year
			Fireblight	May to June
Crataegus (Hawthorn)	Insects	xx	Aphids	April to September
		x	Lacebugs	June to early August
		x	Leafminers	late May to July
			Lecanium scale	July
			Obliquebanded leafroller	June
			San Jose scale	June, August
			Yellownecked caterpillar	August to September
		x	Wooly apple aphid	July to September
	Diseases	xx	Fireblight	May to June
		xx	Rust	June to August
		x	Scab	May to August
Euonymus (Euonymus)	Insects	xx	Aphids	April to September
		x	Black vine weevil	late May to September
		x	Euonymus caterpillar	June
		x	Euonymus scale	late May to August
			Lecanium scale	July
		x	Spider mites	July to August
	Diseases		Anthracnose	May to June
			Crown gall	all year
			Leafspots	June to September
			Powdery mildew	July to August
Forsythia (Forsythia)	Insects	x	Four-lined plantbug	June to July
		x	San Jose scale	June, August (crawlers)
	Diseases		Crown gall	all year
			Leafspots	June to September
Fraxinus (Ash)	Insects	xx	Aphids	April to September
			Ash borer/lilac borer	early June
			Ash flower gall mite	April
		xx	Emerald ash borer	all year
		xx	Fall webworm	June to August
			Oystershell scale	June
		xx	Plantbugs	May to early August
	Diseases	xx	Anthracnose	late May to June
			Ash yellows	all year
		x	Cankers	all year
		x	Leafspots	May to September
		xx	Verticillium wilt	July to September

[a] x = pest is present most years but is only occasionally a serious problem; xx = pest is an annual pest problem. *(continued)*

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[c] Found in infested plant stock in Dane County in 2009. No other known incidences in the state.

Table 3. Pests of woody ornamentals and scouting seasons *(continued)*

Host plant			Pest[a]	Scouting season
DECIDUOUS TREES AND SHRUBS				
Gleditsia (Honeylocust)	Insects	xx	Aphids	April to September
			Cottony maple scale	July
		x	Honeylocust plantbug	May to June
			Honeylocust pod gall midge	May to July
		x	Honeylocust spider mite	August
			Leafhoppers	late June to September
			Lecanium scale	July
	Disease	xx	Canker	all year
Juglans (Walnut)	Insects	xx	Aphids	April to September
		xx	Fall webworm	June to August
			Oystershell scale	June
			Poplar-willow borer	late July to August
		x	Spider mites	July to August
			Spiny elm caterpillar	June to August
			Tussock moth	April to May, August
			Yellownecked caterpillar	August to September
			Walnut caterpillar	August to September
Ligustrum (Privet)	Insects		Lilac borer	late May to early June
		x	Privet rust mite	June to September
		x	Privet thrips	June to August
			San Jose scale	June, August
Lonicera (Honeysuckle)	Insect	xx	Honeysuckle leaf rolling aphid	May to September
	Disease	xx	Insolibasidium leaf blight	May to September
Magnolia (Magnolia)	Insect		Magnolia scale	June to September
Malus (Flowering crabapple)	Insects	xx	Aphids	April to September
		xx	Eastern tent caterpillar	April to May
			European red mite	late April to August
		xx	Fall cankerworm	May
		xx	Fall webworm	June to August
		xx	Gypsy moth	early April to late August
		xx	Japanese beetle	June to September
			Leafhoppers	late June to September
			Lecanium scale	July
			Obliquebanded leafrollers	June
			Oystershell scale	June
			Pear slug sawfly	late May to June
		x	San Jose scale	June, August
			Shothole borer	May to June
		x	Spider mites	July to August
		xx	Spring cankerworm	May
			Tussock moth	April to May, August
		x	Wooly apple aphid	July to September
			Yellownecked caterpillar	August to September

[a] x = pest is present most years but is only occasionally a serious problem; xx = pest is an annual pest problem. *(continued)*

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Table 3. Pests of woody ornamentals and scouting seasons *(continued)*

Host plant			Pest[a]	Scouting season
DECIDUOUS TREES AND SHRUBS				
Malus (Flowering crabapple) *(continued)*	Diseases	xx	Fireblight	May to June
		x	Powdery mildew	July to September
		xx	Rust	June to September
		xx	Scab	May to August
Physocarpus (Ninebark)	Insect	xx	Aphids	April to September
Populus (Poplar)	Insects		Elm sawfly	early May to mid-June
			Fall webworm	June to August
			Leaf beetle	May to August
			Lecanium scale	July
			Oystershell scale	June
			Poplar-willow borer	late July to August
			Vagabond aphid	mid-June
	Diseases		Cankers	all year
		xx	Dothichiza canker	all year
			Leaf blister	May to June
			Septoria leafspot	July to September
Prunus (Flowering plum, etc)	Insects	xx	Aphids	April to September
		xx	Eastern tent caterpillar	April to May
		x	European red mite	late April to August
		xx	Fall cankerworm	May
		xx	Fall webworm	June to August
		xx	Gypsy moth	early April to late August
		xx	Japanese beetle	June to September
			Lecanium scale	July
		x	Lesser peachtree borer	mid-June to early July
			Obliquebanded leafroller	June
		x	Oystershell scale	June
			Peachtree borer	mid-June to early July
		x	Pear slug sawfly	late May to June
		x	San Jose scale	June, August
		xx	Spring cankerworm	May
		x	Spider mite	July to August
			Yellownecked caterpillar	August to September
	Diseases	xx	Bacterial leafspot & canker	June to July
		x	Black knot	all year
		x	Powdery mildew	July to August
		x	Virus	all year

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Table 3. Pests of woody ornamentals and scouting seasons *(continued)*

Host plant			Pest[a]	Scouting season
DECIDUOUS TREES AND SHRUBS				
Quercus (Oak)	Insects	xx	Aphids	April to September
		xx	Fall cankerworm	May
		xx	Fall webworm	June to August
		x	Galls	all year
		xx	Gypsy moth	early April to late August
			Lacebug	June to early August
			Lecanium scale	July
			Oak leafminer	May to July
			Oak leaf skeletonizer	June to August
		x	Spider mites	July to September
		xx	Spring cankerworm	May
			Twig pruner	August to September
			Two-lined chestnut borer	all year
			Yellownecked caterpillar	August to September
	Diseases	x	Anthracnose	late May to June
		xx	Leaf spots	July to September
		xx	Oak wilt	July
		x	Root & butt rot	all year
	Misc.	xx	Alkaline soil induced chlorosis	June to September
Rhus (Sumac)	Insects	xx	Aphids	April to September
		x	Cottony maple scale	July
			Four-lined plantbug	June to July
Ribes (Currant)	Insects	xx	Aphids	April to September
		x	San Jose scale	June, August
Rosa (Rose)	Insects	xx	Aphids	April to September
			Four-lined plantbug	June to July
		xx	Japanese beetle	June to September
			Leafhoppers	late June to September
			Mossyrose gall wasp	May
			Obliquebanded leafroller	June
			Rose chafer	June to July
		x	Roseslug sawfly	June
			Rose stem girdler	July to October
			San Jose scale	June, August
			Spider mites	July to September
	Diseases		Bacterial leafspot	May to July
		xx	Black spot	June to October
			Botrytis	May to September
			Crown gall	all year
			Fire blight	May to September
		x	Powdery mildew	July to August

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Table 3. Pests of woody ornamentals and scouting seasons *(continued)*

Host plant			Pest[a]	Scouting season
DECIDUOUS TREES AND SHRUBS				
Salix (Willow)	Insects	xx	Aphids	April to September
			Elm sawfly	July to August
		xx	Fall webworm	June to August
			Imported willow leaf beetle	June to July
			Lecanium scale	July
			Oystershell scale	June
		x	Yellow poplar weevil	late July to August
Sorbus (Mountain ash)	Insects	x	European red mite	late April to August
		x	Lacebugs	June to early August
		x	Mountain ash sawfly	late May to early July, mid-August
			Oystershell scale	late May to June
		x	Pear blister mite	June to July
			San Jose scale	June, August
			Wooly apple aphid	July to September
	Diseases	x	Cytospora canker	all year
		xx	Fireblight	May
		x	Leaf spots	July to September
		xx	Scab	May to August
Spiraea (Spirea)	Insects	xx	Aphids	April to September
		x	Obliquebanded leafroller	June
	Diseases		Crown gall	all year
			Fireblight	May to June
			Leafspot	May to September
			Powdery mildew	July to August
Syringa (Lilac)	Insects	x	Lilac borer	late May to early July
		x	Oystershell scale	June
	Diseases	xx	Bacterial blight	May to June
		xx	Powdery mildew	July to August
			Witches' broom	all year
Tilia (Linden)	Insects	xx	Aphids	April to September
			Eriophyid gall mites	April to October
		xx	Fall cankerworm	May
			Fall webworm	June to August
		xx	Gypsy moth	early April to late August
		x	Introduced basswood thrips	May
		xx	Japanese beetle	June to September
			Lecanium scale	July
		x	Linden borer	May to August
			San Jose scale	June, August
		xx	Spring cankerworm	May
			Tussock moth	April to May, August
			Yellownecked caterpillar	August to September

[a] x = pest is present most years but is only occasionally a serious problem; xx = pest is an annual pest problem. *(continued)*

[b] Only on Pagoda dogwood *(Cornus alternifolia)*

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Table 3. Pests of woody ornamentals and scouting seasons *(continued)*

Host plant			Pest[a]	Scouting season
DECIDUOUS TREES AND SHRUBS				
Ulmus (Elm)	Insects	xx	Aphids	April to September
		x	Elm leaf beetle	mid-May to September
			Elm leafminer	May to June
			Elm sawfly	late June to July
			Fall cankerworm	May
			Fall webworm	May to August
		xx	Gypsy moth	early April to late August
			Leafhopper	late June to September
			Lecanium scale	July
			Spider mites	July to August
			Spiny elm caterpillar	May to August
			Spring cankerworm	May
			Wooly apple aphid	September to June
			Yellownecked caterpillar	August to September
	Diseases		Bacterial wetwood (slime flux)	all year
		x	Canker	all year
		x	Dutch elm disease	May to July
		x	Leaf blister	May to June
		x	Leaf spots	June to September
		x	Verticillium wilt	April to September
Viburnum (Viburnum)	Insects	xx	Aphids	April to September
			Four-lined plantbug	June to July
		x	Shoot borers	June
		x	Viburnum crown borer	mid-June to early July
			Viburnum leaf beetle[c]	May to October
		x	Viburnum shoot sawfly	late June to August
	Diseases		Bacterial leafspot	May to June
			Botrytis shoot blight	May to September
			Crown gall	all year
			Downy mildew	May to September
			Powdery mildew	July to August

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[b] Only on Pagoda dogwood (Cornus alternifolia)
[c] Found in infested plant stock in Dane County in 2009. No other known incidences in the state.

DISEASE MANAGEMENT

The best disease management strategy involves prevention. The following list details general practices for managing diseases of woody ornamentals:

- Choose disease-resistant cultivars.
- Remove infected tissue whenever possible to reduce the amount of inoculum present, thereby reducing the spread of disease.
- Prune and handle infected trees only during dry periods. Disinfect tools in a 70% alcohol or a 10% bleach solution for 3 minutes between trees.
- Use pathogen-free stock whenever possible.
- Remove infected trees in windbreaks and surrounding areas to prevent the spread of inoculum to susceptible nursery plants.
- Monitor trees closely for signs of disease.
- Avoid accepting uncertified nursery stock. Although the plant material may appear healthy, soil-borne pathogens may be present in container or B&B stock.
- Do not borrow or lend equipment between nurseries unless it is thoroughly washed with high pressure water and a decontamination solution (bleach or fungicide). Wash at the pesticide washing site to prevent spread of debris.
- Keep seedlings as unstressed as possible. Avoid over- and underwatering, herbicide injury, and pest problems.
- Minimize transplanting; use root pruning on appropriate species to limit root size.
- Minimize the number of times you enter the planting beds with equipment, as infested soil is transported on equipment.

STORAGE DISEASE PROBLEMS

Cultural methods are best for managing storage diseases. How the plant material is handled in the fall prior to storage significantly affects its susceptibility to pathogens. Plant material must be properly hardened off and kept dry. The temperature in the storage facility must be monitored and humidity must be kept low. Examine all stored plant materials for signs of infection or decay throughout the winter.

PROPAGATION CONCERNS

The most important practice in preventing the spread of disease during propagation is to propagate from disease-free stock under sanitary conditions.

Sterilize equipment using 70% isopropyl alcohol, Physan 20, or monochloramine. To prepare monochloramine, dissolve 4.6 grams of ammonium sulfate into one gallon of water and add 34 ml of 5% household bleach.

Physan 20 may also be used to effectively disinfect hard surfaces.

To disinfect cuttings, Agrigrom may be used in continuous flow systems. Rinse cuttings in a 15 ppm solution of chlorinated water, then dip into a 200 ppm concentration of Physan 20.

References to fungicides in this publication are for your convenience and are not an endorsement of one product or manufacturer over another. In some situations, the efficacy and phytotoxic effects of these products have not been tested and results may vary. Please refer to the product label for specific rates and application instructions as well as other site and use restrictions and precautions.

Table 4. FUNGICIDES—Common names, trade names, and product information

Common name	Trade name	Manufacturer	Mobility[a]	Group[b]	Risk[c]	Signal word	Notification	REI (hours)	Oral LD_{50}	Dermal LD_{50}
azoxystrobin	Heritage	Syngenta	SU	11	H	caution	either	4	>5,000	>2,000
boscalid + pyraclostrobin	Pageant	BASF	LP, LP	11, 7	–	caution	either	12	–	–
captan	Captan, Captec	Micro Flo, Arysta	PC	M4	L	danger	either	96*	>5,000	>2,000
chlorothalonil	Quali-Pro, Daconil, Chlorothalonil 720	Quali-Pro, Syngenta, Arysta	PC	M5	L	warning	either	48	>10,000	>10,000
chlorothalonil + thiophanate-methyl	Peregrine, Spectro, TM + CTN	Phoenix, Cleary, Nufarm	PC, SU	M5, 1	—	danger	either	12*	—	—
copper	Camelot	Whitmire	PC	M1	L	caution	either	12	4,000	>2,000
copper + mancozeb	Junction	SePRO	PC	M1, M3	—	danger	either	24	—	—
copper hydroxide	Champion, Kocide, Kentan, Nu-Cop	Nufarm, Griffin, Isagro, Agristar	PC	M1	L	caution-danger	varies	24	846–1,346	>2,000–>5,000
copper sulfate	Phyton 27, Cuprofix, Bordeaux Mix	Phyton Co., UPI, Hi-Yield	PC	M1, M2	L	caution	either	24	472	—
cyazofamid	Segway	FMC	PC	21	M-H	caution	either	12	>2,000	>5,000
dimethomorph	Stature[f]	BASF	LP	15	L-M	caution	either	12	3,900	>2,000
etridiazole	Terrazole[f], Terrazole L, Truban[f]	Chemtura, OHP, Scotts	PC	14	L-M	caution-danger	either	12*	1,077	>5,000
etridiazole + thiophanate-methyl	Banrot[f]	Scotts	PC, SU	14, 1	—	warning	either	12	—	—
fenarimol	Rubigan	Gowan	SU	3	M	caution	either	12	>2,000	>4,000
fenhexamid	Decree[d]	SePRO	LP	17	L-M	caution	either	12	>5,000	>5,000
fludioxonil	Medallion	Syngenta	PC	12	L-M	caution	either	12*	>5,000	>2,000
fludioxonil + mefenoxam	Hurricane	Syngenta	PC, SU	12, 4	–	caution	either	48	–	–
flutolanil	Contrast[f], Prostar	Scotts, Bayer	SU	7	M	caution	either	12	>10,000	>5,000

* Restricted entry interval may be longer or shorter than shown here; consult the product label for details. *(continued)*

[a] Pesticide mobility: PC = protective-contact, LP = local penetrant (locally systemic); SU = systemic—upward only; S = systemic

[b] The Fungicide Resistance Action Committee (FRAC) organized fungicides into mode-of-action groups. Active ingredients within a group affect pathogens in the same way.

[c] Risk for development of fungal resistance: L = low, M = medium, H = high.

[d] Not for use in residential landscapes.

[e] Not for use in nurseries.

[f] For use in nurseries only.

Table 4. FUNGICIDES—Common names, trade names, and product information *(continued)*

Common name	Trade name	Manufacturer	Mobility[a]	Group[b]	Risk[c]	Signal word	Notification	REI (hours)	Oral LD_{50}	Dermal LD_{50}
fosetyl-aluminum	Aliette, Flanker[d]	Bayer, Tessenderla Kerley	S	33	L	caution	either	12	5,000	>2,000
iprodione	18 Plus[d], 26GT[d], Chipco 26019[d], Iprodione Pro[d]	Lesco, Bayer, OHP, BASF	LP	2	M-H	caution	either	12	>4,400	>2,000
iprodione + thiophanate-methyl	Cleary 26/36[d], TwoSome[d]	Cleary, Lesco	LP, SU	2,1	–	warning	dual	12	–	–
kresoxim-methyl	Cygnus[d]	BASF	LP	11	H	caution	either	12	>5,000	>2,000
mancozeb	Dithane, Fore, Formec[e], Lesco Mancozeb, Pentathlon, Protect, Penncozeb	Dow AgroSciences, Gordon's, Lesco, SePRO, Cleary, UPI	PC	M3	L	caution	either	24	>5,000	>5,000
mancozeb + thiophanate-methyl	Zyban, Clevis	Scotts, Prokoz	PC, SU	M3, 1	—	caution	either	12	—	—
mefenoxam	Ultra Flourish, Subdue, Subdue Maxx	Nufarm, Syngenta	SU	4	H	caution-warning	either	48*	1,172	>2,020
myclobutanil	Eagle, Rally[f], Hoist	Dow AgroSciences, Prokoz	SU	3	M	caution-warning	either	24	1,600	>5,000
neem oil	Rose Rx, Triact, Trilogy	Bonide, OHP, Certis	PC	—	—	caution	either	4	>5,000	—
phosphorous acid and salts	Alude, Magellan, Vital, Rampart	Cleary, Nufarm, Phoenix, Loveland	S	33	L	caution	either	4	>5,000	>5,000
potassium bicarbonate	Armicab, Kaligreen, GreenCure	Helena, Otsuka, H&I Agritech	PC	—	L	caution	either	4	2,700	>5,000
propamocarb-hydrochloride	Banol[d], Proplant[d]	Bayer, Sipcam	SU	28	L-M	caution	varies	24	2,000-8,550	>3,920

* Restricted entry interval may be longer or shorter than shown here; consult the product label for details. *(continued)*

[a] Pesticide mobility: PC = protective-contact, LP = local penetrant (locally systemic); SU = systemic—upward only; S = systemic

[b] The Fungicide Resistance Action Committee (FRAC) organized fungicides into mode-of-action groups. Active ingredients within a group affect pathogens in the same way.

[c] Risk for development of fungal resistance: L = low, M = medium, H = high.

[d] Not for use in residential landscapes.

[e] Not for use in nurseries.

[f] For use in nurseries only.

Table 4. FUNGICIDES—Common names, trade names, and product information *(continued)*

Common name	Trade name	Manufacturer	Mobility[a]	Group[b]	Risk[c]	Signal word	Notification	REI (hours)	Oral LD_{50}	Dermal LD_{50}
propiconazole	Alamo, Banner Maxx, ProPensity, Propiconazole, Procon-Z, Strider, Spectator	Syngenta, Sipcam, Loveland, Cleary, Lesco	SU	3	M	caution-warning	either	24*	1,517	>4,000
streptomycin	Ag-Streptomycin, Firewall	MANA, Sipcam	—	25	H	caution	either	12	>10,000	325
tebuconazole	Torque	Cleary	SU	3	M	caution	either	12	3,776	>2,000
thiabendazole	Arbotect	Syngenta	SU	1	H	caution	either	0	3,100	>2,000
thiophanate-methyl	Cleary 3336, Fungo, OHP 6672, Tee-Off, T-Storm, PrimeraOne-TM	Cleary, Scotts, OHP, Sipcam, Lesco, UPI	SU	1	H	caution	either	12*	7,500	>10,000
triadimefon	Bayleton, Lesco Systemic[e], Strike[d]	Bayer, Lesco, OHP	SU	3	M	caution	either	12	812	>2,000
trifloxystrobin	Compass, Compass-O	Bayer, OHP	LP	11	H	caution	either	12*	>4,000	>2,000
trifloxystrobin + triadimefon	Armada	Bayer	LP, SU	11, 3	–	caution	either	12*	–	–
triflumizole	Terraguard	Chemtura	SU	3	M	caution	either	12*	2,230	>2,000

* Restricted entry interval may be longer or shorter than shown here; consult the product label for details.

[a] Pesticide mobility: PC = protective-contact, LP = local penetrant (locally systemic); SU = systemic—upward only; S = systemic

[b] The Fungicide Resistance Action Committee (FRAC) organized fungicides into mode-of-action groups. Active ingredients within a group affect pathogens in the same way.

[c] Risk for development of fungal resistance: L = low, M = medium, H = high.

[d] Not for use in residential landscapes.

[e] Not for use in nurseries.

[f] For use in nurseries only.

Table 5. Diseases of CONIFERS

Disease (Pathogen)	Host plants	Fungicide	Remarks
Needle disorders			
Brown spot *(Mycosphaerella dearnessii)*	*Pinus sylvestris*	**H** chlorothalonil, chlorothalonil + thiophanate-methyl, copper + mancozeb, **H** copper hydroxide, **H** mancozeb, mancozeb + myclobutanil	Apply twice between late April and early July. Make first application when needles are half elongated and the second application about 3 weeks later. **Cultural control.** If few trees are diseased, remove and destroy all diseased trees to prevent further dissemination of the disease. Avoid growing short-needled varieties, which are very susceptible.
Cyclaneusma needlecast *(Cyclaneusma minus)*	*Pinus sylvestris*	azoxystrobin, **H** chlorothalonil, chlorothalonil + thiophanate-methyl, copper + mancozeb, **H** copper hydroxide, **H** mancozeb	Make three applications, at 2- to 3-week intervals, from mid-April, before the buds open, through late July. It may be necessary to continue applications through the fall in severe cases. Read the label as application times vary for different formulations.
Dothistroma needlecast *(Mycosphaerella septosporum, Dothistroma pini)*	*Pinus mugo, Pinus nigra*	**H** copper, copper + mancozeb, **H** copper hydroxide, **H** copper sulfate	Make the first application in mid-May. Apply the second treatment between mid-June and mid-July to protect the current and previous season's needles. **Cultural control.** Plant resistant varieties.
Lophodermium needlecast *(Lophodermium seditiosum)*	*Pinus resinosa, Pinus sylvestris*	azoxystrobin, **H** chlorothalonil, chlorothalonil + thiophanate-methyl, copper + mancozeb, **H** copper hydroxide, **H** mancozeb	If more than 10% of all susceptible trees show symptoms from April through June, apply a protective fungicide with a spreader-sticker 3–4 times at 2- to 3-week intervals from late July through October. **Cultural control.** Disease often occurs on the lower part of the tree while winter injury, which expresses similar symptoms, appears on the upper half of the tree. To reduce the incidence of disease, thin plantings to increase air circulation. Plant only disease-free stock. Irrigate early in the day to allow adequate drying time. Avoid growing short-needled varieties.
Rhizosphaera needlecast *(Rhizosphaera kalkhoffii, Rhizosphaera pini)*	*Abies, Picea*	**H** chlorothalonil, chlorothalonil + thiophanate-methyl, **H** copper, **H** copper hydroxide, **H** mancozeb	Apply when needles are half elongated and repeat again after needles are fully elongated.

(continued)

Table 5. Diseases of CONIFERS *(continued)*

Disease (Pathogen)	Host plants	Fungicide	Remarks
Swiss needlecast *(Phaeocryptopus gaeumanni)*	*Pseudotsuga menziesii*	azoxystrobin, **H** chlorothalonil, chlorothalonil + fenarimol, chlorothalonil + thiophanate-methyl, **H** copper, copper + mancozeb, **H** copper hydroxide, **H** mancozeb	Treat in spring when new shoots are 1/2 to 2 inches long. Make a second application 2–3 weeks later. **Cultural control**. Remove vegetation around the base of the tree to increase air circulation. Plant resistant varieties.
Root rots	**Refer to Root and collar disorders in Table 6.**		
Shoot tip disorders			
Phomopsis twig blight *(Phomopsis juniperovora)*	*Juniperus*	azoxystrobin, chlorothalonil + thiophanate-methyl, **H** copper, copper + mancozeb, **H** copper hydroxide, **H** copper sulfate, **H** mancozeb, mancozeb + thiophanate-methyl, **H** propiconazole, **H** thiophanate-methyl	Begin applications, at labeled intervals, when new flushes of growth appear; protect until foliage is mature. **Cultural control.** It is important to remove and destroy dead and infected twigs. Resistant species and varieties are available.
Diplodia shoot blight *(Diplodia pinea)*	*Pinus mugo, Pinus nigra, Pinus resinosa, Pinus sylvestris*	azoxystrobin, chlorothalonil + thiophanate-methyl, **H** myclobutanil, **H** propiconazole, **H** thiophanate-methyl, **H** triadimefon	Apply in early April through mid-June. Follow label directions. Not proven to be a reliable control. **Cultural control.** Plant disease-free stock. Monitor windbreaks for source of inoculum. Prune only during dry periods and control insects since wounded tissue remains susceptible for several days. Remove red pine windbreaks.
Stem and branch disorders			
Cytospora canker *(Cytospora kunzei)*	*Abies, Picea, Pinus, Pseudotsuga menziesii, Tsuga*	none	**Cultural control.** Minimize stress and increase vigor by providing adequate moisture and nutrients. Avoid deep cultivation near the trunk. Avoid wounding branches and trunk, particularly during wet periods. Monitor spruce regularly for early symptoms of cytospora canker. Prune out infected branches during dry weather.

H = Formulations of this active ingredient intended for homeowner use are available.

Table 6. Diseases of DECIDUOUS TREES & SHRUBS

Disease (Pathogen)	Host plants	Fungicide	Remarks
Cankers	Cankers are best managed through prevention. When pruning, do not leave stubs or cut into the branch collar. During the growing season, prune only during dry periods. Remove all infected debris and sanitize equipment in 70% ethanol or a 10% bleach solution between cuts. Trees under stress or with poor vigor are less able to fight infection.		
Birch canker *(Neonectria ditissima)*	*Betula*	none	**Cultural control.** Remove cankered branches. Maintain proper moisture and fertility.
Black knot *(Apiosporina morbosa)*	*Prunus*	copper + mancozeb, **H** copper sulfate, **H** thiophanate-methyl	Apply lime-sulfur as a dormant application after pruning or apply thiophanate-methyl when dormant, at pinkbud, at petal-fall, and again 3 weeks later. If symptoms are severe, spray for two consecutive years. **Cultural control.** Remove and destroy infected branches 6–8 inches below the knot while the tree is dormant. Remove wild *Prunus* within 600 ft of nursery stock.
Fire blight *(Erwinia amylovora)*	*Chaenomeles, Cotoneaster, Crataegus, Cydonia, Malus, Pyrcantha, Pyrus, Rosa, Sorbus aucuparia, Spiraea*	**H** copper, copper + mancozeb, **H** copper hydroxide, **H** copper sulfate, fosetyl-aluminum, phosphorous acid, streptomycin	Apply copper sulfate during the dormant season. Streptomycin is effective only during bloom. **Cultural control.** Prune branches to at least 12 inches below cankers. Plant resistant varieties. Remove or disk fallen infected leaves at the end of the season. Excessive new growth (due to heavy pruning or too much nitrogen) is at high risk for infection.
Nectria canker *(Nectria cinnabarina)*	*Gleditsia triacanthos*	none	**Cultural control.** Prevent stress to trees. Avoid pruning during the dormant season to prevent infection.
Phomopsis canker *(Phomopsis arnoldiae)*	*Elaeagnus angustifolia*	none	**Cultural control.** Plant healthy trees, avoid spreading the disease with contaminated tools. Remove and destroy infected branches and severely infected trees.

(continued)

Table 6. Diseases of DECIDUOUS TREES & SHRUBS *(continued)*

Disease (Pathogen)	Host plants	Fungicide	Remarks
Foliage diseases	Many foliage disease problems are more severe in nurseries than in private landscapes. Chemical control is usually only recommended when the tree's health is poor; a severe infection may predispose an already stressed tree to more severe pest complexes. Most fungicides are preventative in action and provide little benefit once the infection becomes severe. Foliage diseases may be dealt with in the nursery by rotation, fall cleanup, and the selection of resistant varieties.		
Anthracnose *(Colletotrichum, Discula, Marssonia,* and others)	*Acer, Aesculus, Betula, Carya, Cornus, Fraxinus, Juglans, Malus, Platanus occidentalis, Populus, Quercus*	azoxystrobin, boscalid + pyraclostrobin, **H** chlorothalonil, chlorothalonil + thiophanate-methyl, **H** copper, copper + mancozeb, **H** copper hydroxide, **H** copper sulfate, kresoxim-methyl, **H** mancozeb, mancozeb + thiophanate-methyl, **H** myclobutanil, **H** neem oil, phosphorous acid and salts, **H** potassium bicarbonate, **H** propiconazole, tebuconazole, thiabendazole, **H** thiophanate-methyl, trifloxystrobin, trifloxystrobin + triadimefon, triflumizole	Apply at budbreak, when leaves are fully expanded and again 2 weeks later. Thiabendazole is labeled for use as an injection treatment on *Platanus* to temporarily suppress internal infections; it is to be used by someone trained in injection techniques. **Cultural control.** Remove and destroy all fallen, diseased leaves. Prune diseased twigs and branches.
Bacterial leafspot & twig blight *(Pseudomonas syringae* pv. *syringae)*	*Prunus, Syringa*	**H** copper, copper + mancozeb, **H** copper hydroxide, **H** copper sulfate, fosetyl-aluminum, phosphorous acid	Apply 3 times at 7- to 10-day intervals beginning in early May when leaves unfold and symptoms develop. **Cultural control.** Practice control on young stock and propagation material.

(continued)

Table 6. Diseases of DECIDUOUS TREES & SHRUBS *(continued)*

Disease (Pathogen)	Host plants	Fungicide	Remarks
Botrytis blight, Gray mold *(Botrytis cinera)*	*Berberis, Cornus, Corylus, Cotoneaster, Crataegus, Euonymus, Fagus, Magnolia, Malus, Prunus, Pyrus, Rosa, Syringa, Viburnum*	azoxystrobin, captan, **H** chlorothalonil, **H** copper, copper + mancozeb, **H** copper sulfate, fenhexamid, fludioxonil, iprodione, iprodione + thiophanate-methyl, **H** mancozeb, trifloxystrobin, triflumazole	Apply chlorothalonil, iprodione, or mancozeb preventatively. **Cultural control.** Cut and remove dead and dying tissue from plants. Remove dead tissue from soil surface. Reduce humidity around plants. Avoid overhead irrigation if possible.
Downy mildew *(Peronospora spp., Plasmopara spp., Pseudoperonospora spp.)*	*Rosa, Viburnum*	**H** chlorothalonil, **H** copper, **H** copper sulfate, fosetyl-aluminum, **H** mancozeb, mefenoxam, **H** neem oil, **H** potassium bicarbonate, trifloxystrobin	Several fungicides are labeled for control of downy mildew. **Cultural control.** Increase air flow between plants. When planting a new area, space plants far apart to maximize air flow between plants. Choose resistant varieties when available.
Powdery mildew—Numerous species of fungi	Numerous hosts	azoxystrobin, boscalid + pyraclostrobin, chlorothalonil + thiophanate-methyl, copper + mancozeb, **H** copper hydroxide, **H** copper sulfate, fenarimol, kresoxim-methyl, **H** myclobutanil, mancozeb + thiophanate-methyl, neem oil, phosphorous acid and salts, **H** potassium bicarbonate, **H** propiconazole, tebuconazole, **H** thiophanate-methyl, **H** triadimefon, trifloxystrobin, trifloxystrobin + triadimefon, triflumizole	Apply at 1- to 2-week intervals once symptoms appear. **Cultural control.** Plant resistant cultivars. Remove and destroy diseased tissue and increase air circulation.

(continued)

Table 6. Diseases of DECIDUOUS TREES & SHRUBS *(continued)*

Disease (Pathogen)	Host plants	Fungicide	Remarks
Rusts: Cedar-apple rust *(Gymnosporangium juniperi-virginianae),* cedar-hawthorn rust *(G. globosum),* and cedar-quince rust *(G. claviceps)*	*Amelanchier, Chaenomeles, Crataegus, Malus, Sorbus*	boscalid + pyraclostrobin, **H** chlorothalonil, chlorothalonil + thiophanate-methyl, **H** copper sulfate, flutolanil, kresoxim-methyl, **H** mancozeb, mancozeb + thiophanate-methyl, **H** myclobutanil, **H** propiconazole, tebuconazole, **H** thiophanate-methyl, **H** triadimefon, trifloxystrobin, trifloxystrobin + triadimefon, triflumizole	Treat susceptible deciduous hosts 4–5 times, at labeled intervals, in the spring when telial galls (or branch swellings due to cedar-quince rust) are fruiting on *Juniperus* hosts. **Cultural control.** Plant resistant species and varieties. To reduce disease potential, eliminate susceptible and unprotected host species within several hundred feet (ideally, up to several miles) of the nursery.
	Juniperus	azoxystrobin, **H** copper, copper + mancozeb, flutolanil, **H** mancozeb, mancozeb + thiophanate-methyl, **H** myclobutanil, propiconazole, tebuconazole, **H** triadimefon, trifloxystrobin, trifloxystrobin + triadimefon	Treat valuable and susceptible *Juniperus* in the summer when orange spores are being released from aecia (tubes or minute cups) found on the underside of deciduous host leaf spots. For cedar-quince rust, aecial tubes are on twigs and fruit of Crataegus and Amelanchier. **Cultural control.** Plant resistant species and varieties. To reduce disease potential, eliminate susceptible and unprotected host species within several hundred feet (ideally, up to several miles) of the nursery.
Scab *(Venturia inaequalis)*	*Malus, Sorbus aucuparia*	boscalid + pyraclostrobin, **H** chlorothalonil, chlorothalonil + thiophanate-methyl, **H** copper hydroxide, kresoxim-methyl, **H** mancozeb, mancozeb + thiophanate-methyl, **H** myclobutanil, neem oil, phosphorous acid and salts, **H** propiconazole, **H** thiophanate-methyl, trifloxystrobin, trifloxystrobin + triadimefon, triflumizole	Apply 4–5 times at 10-day intervals beginning at budbreak. **Cultural control.** Plant disease-resistant cultivars. Remove and destroy all fallen, infected leaves.

(continued)

Table 6. Diseases of DECIDUOUS TREES & SHRUBS *(continued)*

Disease (Pathogen)	Host plants	Fungicide	Remarks
Septoria leafspot *(Septoria species)*	Numerous hosts	azoxystrobin, **H** chlorothalonil, chlorothalonil + fenarimol, chlorothalonil + thiophanate-methyl, copper + mancozeb, **H** copper sulfate, kresoxim-methyl, **H** mancozeb, mancozeb + thiophanate-methyl, **H** propiconazole, tebuconazole, thiophanate-methyl, trifloxystrobin, trifloxystrobin + triadimefon	
Root and collar disorders	Affects all plants. Because most roots are located in the top 18 inches of soil, any disturbance within the rootzone—including cultivation—may predispose that plant to problems. Root and collar disorders are often a result of poor drainage. Root rot problems in propagation beds and mist chambers should be controlled with fungicides. Once disease occurs, it is often very difficult to control.		
Crown gall *(Agrobacterium tumefaciens)*	Numerous hosts	none	**Cultural control.** Practice good sanitation. Avoid wounds to Rosaceous hosts.
Root rots *(Cylindrocladium, Fusarium, Rhizoctonia,* and *Thielaviopsis)*	Numerous hosts	azoxystrobin, boscalid + pyraclostrobin, chlorothalonil + thiophanate-methyl, etridiazole + thiophanate-methyl, fludioxonil, fludioxonil + mefenoxam, iprodione, **H** thiophanate-methyl, trifloxystrobin, triflumizole	May be very difficult to control. Sanitation is important to prevent the spread of disease.
Root rots *(Pythium* and *Phytophthora)*	Numerous hosts	boscalid + pyraclostrobin, cyazofamid, dimethomorph, etridiazole, etridiazole + thiophanate-methyl, fludioxonil + mefenoxam, fosetyl-aluminum, mefenoxam, phosphorous acid and salts, propamocarb-hydrochloride, trifloxystrobin	May be very difficult to control. Sanitation is important to prevent the spread of disease.

Table 6. Diseases of DECIDUOUS TREES & SHRUBS

Disease (Pathogen)	Host plants	Fungicide	Remarks
Vascular diseases	**Curative systemic fungicides are of little value once a tree is infected because the vascular system is impaired.**		
Ash yellows, Lilac witches' broom *(Candidatus Phytoplasma fraxini)*	*Fraxinus, Syringa*	None	Ash yellows has no known cure. Diseased trees may grow slowly for several years. Contact your local Extension agent if you believe that your true ash trees *(Fraxinus spp.)* have ash yellows. **Cultural control.** When planting lilacs, choose species or varieties with tolerance to the ash yellows phytoplasma. Common lilacs *(Syringa vulgaris)* and varieties of that species as well as *S. relexa* and *S. villosa* are tolerant of the ash yellows phytoplasma. Avoid using *S. josikaea, S. reticulata,* and *S. sweginowii.*
Dutch elm disease *(Ophiostoma ulmi, O. novo-ulmi)*	*Ulmus americana*	propiconazole, thiabendazole	Listed fungicides are labeled for use as a temporary preventive injection; they are to be used by someone trained in injection techniques. **Cultural control.** Implement cultural practices that destroy beetle brood wood, prune diseased limbs, and mechanically separate root grafts.
Oak wilt *(Ceratocystis fagacearum)*	*Quercus*	propiconazole	Listed fungicides are labeled for use as a temporary preventive injection; they are to be used by someone trained in injection techniques. **Cultural control.** Avoid pruning oak trees between April 15 and September 1. If wounds do occur, treat promptly with a wound treatment compound or thick paint to prevent insect infestation. If disease develops in a planting of oaks, sever all root grafts to prevent the disease spread to nearby trees. Burn or bury killed trees the winter immediately after death.
Verticillium wilt (Verticillium dahliae)	*Acer, Aesculus, Amelanchier, Berberis, Buxus, Catalpa, Cercis, Cotinus, Eleaegnus angustifolia, Fraxinus, Gymnocladus, Ligustrum, Liriodendron tulipifera, Lonicera, Magnolia, Prunus, Rhododendron, Rhus, Robinia, Rosa, Spiraea, Syringa, Ulmus, Viburnum, Weigela*	soil fumigants (such as chloropicrin, dazomet, dichloropropene, and metam sodium)	**Cultural control.** Remove and destroy severely diseased trees. Remove as much of the root system as possible. In severe cases, it may be necessary to plant only resistant species on sites with high numbers of *Verticillium* propagules in the soil. A soil test is available to determine the number of propagules present. Control weeds, particularly weeds such as velvetleaf that are susceptible to *Verticillium.* Intensive use of sudan grass as a cover may be beneficial. In fields with a high population of *Verticillium* propagules in the soil, plant only resistant genera, which are: all gymnosperms, *Betula, Carya, Celtis, Chaenomeles, Crataegus, Fagus, Ginkgo, Gleditsia, Juglans, Malus, Populus, Pyrus, Quercus macrocarpa* and *Q. alba, Salix,* and *Sorbus.*

H = Formulations of this active ingredient intended for homeowner use are available.

INSECT MANAGEMENT

PHENOLOGY AND PEST PREDICTION

Effective insect pest management requires an understanding of how pest development relates to weather conditions, particularly temperature. Phenology is the study of the life cycle phases of plants and animals as related to climate. Because insects are cold-blooded, their development is directly correlated to the accumulation of degree days. A degree day (DD) is a unit of measure that occurs for each degree above a base temperature during a 24-hour period. Growing degree days (GDD) are a cumulative total of DDs above a base temperature. The most common base temperature used is 50°F.

To monitor insect development using this system, you will need a maximum/minimum thermometer to obtain the daily high and low temperatures for each 24-hour period. Use the following equations to calculate GDD:

1. (high temp + low temp) ÷ 2 = daily average temperature
2. daily average temperature – 50°F = degree days
3. degree days + cumulative GDD total = new GDD total

Because insect development and plant development both require degree day accumulations, you can use certain plants as indicators of insect events. Table 7 lists plant and insect development at various GDDs. This information is only applicable to the development of insects that overwinter in Wisconsin. Migratory insects, which develop in different climates (such as leafhoppers), cannot be correlated.

Most chemical pest management practices are timed to a particular calendar date. Unless the weather of a given year is that of the 'normal year' these dates may not actually coincide with the most vulnerable lifestage of an insect pest. Degree days and indicator plants can help you better anticipate pest outbreaks.

References to insecticides in this publication are for your convenience and are not an endorsement of one product or manufacturer over another. In some situations, the efficacy and phytotoxic effects of these products have not been tested and results may vary. Please refer to the product label for specific rates and application instructions as well as other site and use restrictions and precautions.

Table 7. Insect and plant development relative to growing degree days (GDD)

GDD	Indicator plant	Pest
50–100	*Magnolia x soulangiana* in pink bud, just before petals open	Cooley spruce gall adelgid adults Eastern spruce gall adelgid adults Eastern tent caterpillar egg hatch Euonymus scale European pine shoot moth larvae Maple bladdergall mite Spruce needleminer larvae
75–100		Viburnum leaf beetle larvae
80	*Dicentra cucularia* in full bloom	Eastern spruce gall adelgid ovipositing
90		Eastern spruce gall adelgid egg hatch Hickory leaf stem gall aphid nymphs
100	*Magnolia* x *soulangiana* in pink bud to early bloom	Eastern tent caterpillar larvae, first instar Zimmerman pine shoot moth larvae

(continued)

Table 7. Insect and plant development relative to growing degree days (GDD) *(continued)*

GDD	Indicator plant	Pest
100–200	*Magnolia* x *soulangiana* in full bloom; dropping petals	Ash plant bug nymphs Cankerworms Elm bark beetle European pine sawfly larvae Fletcher scale crawlers Gypsy moth egg hatch Honeylocust plant bug Spruce spider mite
140		Eastern tent caterpillar larvae, second instar
145		Pine spittlebug egg hatch
150		Cooley spruce gall adelgid ovipositing
200–350	*Spiraea* x *vanhouttei* in bloom	Gypsy moth larvae present Imported willow leaf beetle Pine needle scale crawlers, first generation
210	*Prunus virginiana* in full bloom	Cooley spruce gall adelgid egg hatch
250		Cooley spruce galls forming
265	*Cornus sericea* 'Flaviramea' in bloom	Oystershell scale egg hatch
275–500	*Syringa vulgaris* in late bloom	Ash borer larvae, first instar Birch leafminer larvae Hawthorn leafminer larvae Oystershell scale crawlers (brown race) Taxus mealybug
350		Eastern tent caterpillar larvae, third instar
365		Elm sawfly larvae
400–500	*Spiraea* x *vanhouttei* finished blooming; *Viburnum dentatum* in early bloom	Black vine weevil adult feeding Bronze birch borer larvae Elm leaf beetle larvae feeding Mountain ash sawfly Oystershell scale crawlers (gray race)
450–550	*Robinia pseudoacacia* in bloom	Emerald ash borer adults
500–600	*Spiraea* x *vanhouttei* blossoms brown; *Philadelphus* in bloom	Euonymus scale crawlers Lesser peachtree borer larvae Peachtree borer larvae, first instar Viburnum crown borer larvae, first instar White-marked tussock moth
600		Fletcher scale egg hatch
725		Eastern tent caterpillar adults
850		Cottony maple scale egg hatch Fall webworm larvae Oak spider mite Wooly apple aphid on rosaceae
900		European pine shoot moth adult emergence
900–1200	*Daucus carota* in early bloom; *Hydrangea arborescens* 'Grandiflora' in full bloom	Fletcher scale crawlers, second generation Japanese beetle adults
1500	Vervain and wild bergamot blooming	Pine needle scale egg hatch, second generation

(continued)

Table 7. Insect and plant development relative to growing degree days (GDD) *(continued)*

GDD	Indicator plant	Pest
1600–1700	*Daucus carota* in full bloom; *Hydrangea arborescens* 'Grandiflora' blossoms turn from white to green	Oystershell scale crawlers, second generation (brown race) Pine needle scale crawlers, second generation
1800–2100	*Solidago* in early bloom, *Sorbus* fruit ripe	White-marked tussock moth, second generation
2700–2900	*Viburnum dentatum* fruit ripe	Peachtree and lesser peachtree borers protected within trunk Zimmerman pine moth second generation larvae, first instar
2800–3000	*Hamamelis virginiana* blooming and some plants defoliated	Cooley spruce gall adelgid nymphs, second generation Eastern spruce gall adelgid nymphs, second generation
3000–3200	*Hamamelis virginiana* in late bloom	Spruce needleminer

Sources: Adapted from Donald A. Orton with Thomas L. Green, *Coincide—The Orton System of Pest Management* (Flossmoor, IL: Plantsmen's Publications, 1989); Herms, D.A., McCullough, D.G., Smitley, D.R., Sadof, C., Williamson, R.C., and Nixon, P.L. 2009. Insecticide options for protecting ash trees from emerald ash borer. North Central IPM Center Bulletin. 12 pp.; and from records of the Wisconsin Phenological Society, Department of Geography, Room 474, Bolton Hall, P.O. Box 413, Milwaukee, WI 53201.

Table 8. INSECTICIDES—Common names, trade names, and safety information

Common names	Trade names	Manufacturer	Signal word	Notification	Pesticide class	REI (hours)	Oral LD_{50}	Dermal LD_{50}
abamectin	Avid, Aracinate	Syngenta, Rainbow Treecare	warning	either	avermectin	12	300	>1,800
acephate	Orthene, Acecap	Amvac	caution-danger	either	organophosphate	72	980	70
acequinocyl	Shuttle	Arysta	caution	either	acequinocyl	12	>5,000	>2,000
azadirachtin	Azatin, Azatrol	OHP, Gordon's	caution	either	unknown MOA	4	4,242	>2,000
Bacillus thuringiensis	Thuricide, Dipel, Foray	several	caution	either	microbial	0–4	non-toxic	non-toxic
bidrin	Inject-A-Cide B	Mauget	danger	either	organophosphate	—	22	224
bifenthrin	Onyx, Talstar, Crosscheck	FMC, Lesco	caution	either	synthetic pyrethroid	12	632	>2,000
bifenthrin+ clothianidin	Aloft	Arysta LifeScience	caution	either	pyrethroid, neonicotinoid	12	–	–
carbaryl	Sevin	Bayer, Loveland	caution	either	carbamate	12	281	>2,000
chlorantraniliprole	Acelepryn	DuPont	none	either	anthranilic diamide	4	>5,000	>5,000
clothianidin	Arena	Valent	caution	either	neonicotinoid	12	4,700	>5,000
cryolite	Kryocide	UPI	caution	either	unknown MOA	12	non-toxic	non-toxic
cyfluthrin	Tempo, Decathlon	Bayer, OHP	caution	either	synthetic pyrethroid	12	960	>2,000
cypermethrin	Demon	Syngenta	warning	either	synthetic pyrethroid	12	250	>2,000

(continued)

Table 8. INSECTICIDES—Common names, trade names, and safety information *(continued)*

Common names	Trade names	Manufacturer	Signal word	Notification	Pesticide class	REI (hours)	Oral LD_{50}	Dermal LD_{50}
cyromazine	Citation	Syngenta	caution	either	chitin synthesis inhibitor	12	4,460	>2,010
deltamethrin	DeltaGard T&O, Suspend	Bayer	caution	either	synthetic pyrethroid	12	>5,000	>2,000
diflubenzuron	Dimilin	Chemtura	caution	either	insect growth regulator	12	>4,640	>10,000
dinotefuran	Safari, Transtect, Greenlight Tree & Shrub	Valent, Rainbow Treecare, Greenlight	caution	either	neonicotinoid	12	2,450	>2,000
emamectin benzoate	Tree-äge	Syngenta	warning	either	avermectin	—	3,129	>5,000
esfenvalerate	Asana	DuPont	warning	either	synthetic pyrethroid	12	458	>2,000
etoxazole	TetraSan	Syngenta	caution	either	mite growth inhibitor	12	2,600	>5,000
fenpropathrin	Tame	Valent	warning	either	synthetic pyrethroid	24	66	>2,000
fluvalinate	Mavrik	Wellmark	caution	either	synthetic pyrethroid	12	260	>2,000
hexythiazox	Hexygon	Gowan	caution	either	mite growth inhibitor	12	>5,000	>5,000
horticultural oils (dormant and ultra-fine oils)	several	several	caution	either	horticultural oil	n/a	non-toxic	non-toxic
imidacloprid	Merit, Bayer Advanced, Zenith, Marathon	Bayer, OHP	caution	either	neonicotinoid	12	2,591	>2,000
imidacloprid + clothianidin	Bayer Advanced Protect and Feed II	Bayer	caution	either	neonicotinoid	–	>5,136	>2,000
indoxacarb	Provaunt	DuPont	caution	either	oxadiazine	—	1,867	>5,000
insecticidal soap	several	several	caution	either	insecticidal soap	n/a	non-toxic	non-toxic
lambda-cyhalothrin	Scimitar, Lambda-Cy	Syngenta, UPI	caution-warning	either	synthetic pyrethroid	48	>5,000	>2,000
malathion	Malathion	several	warning	either	organophosphate	12	2,800	1,000
methoxyfen-ozide	Intrepid	Dow	caution	either	moulting hormone agonist	4	>5,000	>2,000
permethrin	Astro, Ambush, Tenguard	FMC, Amvac, UPI	caution	either	synthetic pyrethroid	12	998	>2,000
phosmet	Imidan	Gowen	warning	either	organophosphate	24	147	3,160
pyrethrins	Pyrenone, Pyganic	Bayer, MGK	caution	either	pyrethroid, botanical	12	1,500	>1,800
spinosad	Conserve	Dow AgroSciences	caution	either	spinosyn	4	>5,000	>5,000
sulfur	Lime Sulfur, Dustable Sulfur, MicroSulf, Microthion	Hi-Yield, Nufarm, UPI	caution	either	sulfur	24	820	>2,000
thiamethoxam	Flagship, Meridian	Syngenta	caution	either	neonicotinoid	12	>5,000	>5,000

EPA pesticide cancellations. Several insecticides listed for use on woody ornamentals have recently been phased out (removed from the market). Others are in the process of being phased out, and can still be obtained and used in certain situations. Insecticides such as azinphos-methyl, chlorpyrifos, diazinon, dimethoate, endosulfan, metasystox, methiocarb, methoxychlor, and rotenone fall under this heading. For that reason, these insecticides are mentioned here, but are not elaborated upon in Table 8. WDATCP provides the most up-to-date information on pesticide registration in the state: http://www.kellysolutions.com/wi/.

Table 9. Insect pests and available control options

Insect	Host plants	Insecticide	Remarks
Aphids			
Balsam twig aphid	*Abies*	**H** acephate, **H** bifenthrin + clothianidin, **H** carbaryl, **H** chlorpyrifos*, clothianidin, **H** deltamethrin, **H** dinotefuran, esfenvalerate, **H** imidacloprid, **H** imidacloprid + clothianidin, **H** insecticidal soap, thiamethoxam, **H** ultra-fine oil	Spray after egg hatch but before budbreak in April to reduce the risk to beneficial species. Use only for trees to be sold within 2 years. Apply clothianidin, dinotefuran, imidacloprid, or thiamethoxam as a soil injection or drench in the fall. Spring applications should be made foliarly.
Common aphids	Numerous hosts	**H** acephate, **H** azadirachtin, **H** bifenthrin, bifenthrin + clothianidin, chlorpyrifos*, clothianidin, **H** cyfluthrin, **H** deltamethrin, **H** dinotefuran, fenpropathrin, fluvalinate, **H** imidacloprid + clothianidin, **H** insecticidal soap, **H** lambda-cyhalothrin, malathion, **H** permethrin, **H** pyrethrins, thiamethoxam, **H** ultra-fine oil	Frequently found on new, succulent growth. Repeat applications may be necessary. Insecticide must come into contact with aphid. Apply clothianidin, dinotefuran, imidacloprid, or thiamethoxam as a soil injection or drench in the fall. Spring applications should be made foliarly. **Cultural control.** Beneficial predators and parasites may eventually control population. High-pressure sprays of water may dislodge or kill aphids.
Woolly aphids/ adelgids	*Abies, Crataegus, Malus, Picea, Pinus, Pseudotsuga*	**H** acephate, bifenthrin + clothianidin, chlorpyrifos*, clothianidin, **H** deltamethrin, **H** dinotefuran, **H** dormant oil, esfenvalerate, fluvalinate, **H** imidacloprid, **H** imidacloprid + clothianidin, **H** insecticidal soap, thiamethoxam	Spray foliage thoroughly. Good coverage is necessary for successful control. May require repeat applications. Apply dormant oil during the dormant season to control eggs. Apply clothianidin, dinotefuran, imidacloprid, or thiamethoxam as a soil injection or drench in the fall. Spring applications should be made foliarly.

(continued)

Table 9. Insect pests and available control options *(continued)*

Insect	Host plants	Insecticide		Remarks
Beetles				
Elm leaf beetle	*Ulmus*	**H** acephate, **H** azadirachtin, **H** *Bacillus thuringiensis*, **H** bifenthrin, bifenthrin + clothianidin, **H** carbaryl, chlorpyrifos*, clothianidin, **H** cyfluthrin, **H** deltamethrin, **H** dinotefuran, fluvalinate, **H** imidacloprid, **H** imidacloprid + clothianidin, **H** lambda-cyhalothrin, phosmet, **H** pyrethrins, **H** spinosad, thiamethoxam	Control is recommended if a tree has suffered recent stresses or for high-value ornamentals only. Apply clothianidin, dinotefuran, imidacloprid, or thiamethoxam as a soil injection or drench in the fall. Spring applications should be made foliarly.
Imported willow leaf beetle	*Populus, Salix*	**H** acephate, **H** azadirachtin, **H** *Bacillus thuringiensis*, **H** bifenthrin, **H** carbaryl, chlorpyrifos*, **H** cyfluthrin, **H** deltamethrin, **H** dinotefuran, fluvalinate, **H** imidacloprid, **H** imidacloprid + clothianidin, **H** insecticidal soap, **H** lambda-cyhalothrin, **H** permethrin, **H** spinosad, thiamethoxam	Larvae and adults feed on foliage. Apply dinotefuran, imidacloprid, or thiamethoxam as a soil injection or drench in the fall. Spring applications should be made foliarly.
Japanese beetle	Numerous hosts. Most common hosts: *Betula, Rosa, Tilia*	**H** acephate, **H** azadirachtin, **H** bifenthrin, bifenthrin + clothianidin, **H** carbaryl, chlorpyrifos*, clothianidin, **H** cyfluthrin, **H** deltamethrin, fenpropathrin, **H** imidacloprid, **H** imidacloprid + clothianidin, **H** insecticidal soap, **H** lambda-cyhalothrin, malathion, **H** permethrin, phosmet, **H** pyrethrins, thiamethoxam	Many products should be applied as a soil drench or granules to control grubs; others treat adults and are applied to foliage. May require repeat applications. Apply clothianidin, dinotefuran, imidacloprid, or thiamethoxam as a soil injection or drench in the fall. Spring applications should be made foliarly. **Cultural control.** Pheromone trapping will help detect populations early. Hang traps in early June and monitor through late August.
Borers				
Ash borer (lepidoptera—clearwing moth)	*Fraxinus, Syringa*	**H** bifenthrin, chlorantraniliprole, chlorpyrifos*, emamectin benzoate, **H** permethrin	Apply to trunk and larger branches in mid-June. **Cultural control.** Pheromone traps will aid in timing applications. Hang traps in early June and monitor through late August. Prevent stress to trees.

(continued)

Table 9. Insect pests and available control options *(continued)*

Insect	Host plants	Insecticide	Remarks
Bronze birch borer	*Betula*	**H** bifenthrin, **H** bidrin, **H** chlorpyrifos*, **H** dinotefuran, **H** imidacloprid, **H** imidacloprid + clothianidin, **H** permethrin	Spray trunk and main branches thoroughly. Apply when *Spiraea x vanhouttei* finishes bloom (400–500 GDD) and again 3 weeks later. Apply dinotefuran or imidacloprid as a soil injection or drench in the fall. **Cultural control.** Prevent stress factors such as drought and leafminer attack. The altered starch content in stressed plants makes them more attractive to borers. Proper siting is important.
Eastern pine shoot borer	*Pinus*	**H** bifenthrin, **H** chlorpyrifos*, **H** imidacloprid + clothianidin, phosmet	Apply to trunk and larger branches in mid-May to kill larvae before they bore into the shoots. Once injury is noticed, it is too late for chemical control. **Cultural control.** Shear trees to remove injured shoots.
Emerald ash borer	*Fraxinus*	**H** acephate, **H** bidrin, **H** bifenthrin, **H** carbaryl, **H** cyfluthrin, **H** dinotefuran, **H** emamectin benzoate, **H** imidacloprid, **H** imidacloprid + clothianidin, **H** permethrin	Apply bark and canopy sprays (acephate, bifenthrin, carbaryl, cyfluthrin, permethrin) in early to mid-June for effective control. Multiple applications may be needed. Soil drenches and trunk injections (bidrin, imidacloprid, dinotefuran, emamectin benzoate) should be applied between mid-April to May depending on the size of the tree. Applications can also be made in the fall for protection in the following year.
Lilac borer	*Fraxinus, Syringa*	**H** bifenthrin, **H** chlorantraniliprole, **H** chlorpyrifos*, **H** permethrin	Bark sprays should be applied to the trunk and large branches thoroughly 10–14 days after adult activity is noted in pheromone traps. **Cultural control.** Hang pheromone traps in late May and monitor every other day through late June, then weekly through July. Practice renewal pruning to remove old wood.
Linden borer	*Tilia*	**H** bifenthrin, **H** chlorpyrifos*, **H** dinotefuran, **H** imidacloprid, **H** imidacloprid + clothianidin	Spray trunk and main branches thoroughly in mid-May, mid-June, and mid-July. 'Greenspire' linden is particularly susceptible to borer attack.
Peachtree borer	*Cotinus, Prunus*	**H** bifenthrin, **H** chlorantraniliprole, **H** chlorpyrifos*, **H** permethrin	Treat newly hatched larvae with 2–4 applications about 20 days apart from the time *Philadelphus* blooms (500–600 GDD) until *Viburnum dentatum* fruit ripen (2700–2900 GDD). **Cultural control.** Prevent wounding. Wrap trunks of young trees.

(continued)

Table 9. Insect pests and available control options *(continued)*

Insect	Host plants	Insecticide	Remarks
Shothole borers	Arborvitae, Juniperus, Malus, Pinus	**H** bifenthrin, chlorpyrifos*	Apply thoroughly to trunk and main branches. **Cultural control.** Prevent stress on trees. Remove severely infested trees to prevent spread to healthy trees.
Twolined chestnut borer	*Quercus*	**H** bifenthrin, chlorpyrifos*, **H** dinotefuran, **H** imidacloprid, **H** imidacloprid + clothianidin	**Cultural control.** Handle and store firewood carefully. Cover wood piles from May 15 to July 15. Use a heavy plastic tarp and seal tarp securely with soil along the bottom edges. This will prevent escape of the beetles and reinfestation of nearby trees. Also protect trees from construction injury.
Viburnum crown borer	*Viburnum*	**H** bifenthrin, chlorantraniliprole, chlorpyrifos*	Treat when *Philadelphus* is in bloom (500–600 GDD).
Caterpillars			
Cankerworms	*Acer, Malus, Prunus, Quercus, Tilia, Ulmus*	**H** azadirachtin, **H** *Bacillus thuringiensis* var. *Kurstaki*, **H** bifenthrin, **H** carbaryl, chlorantraniliprole, chlorpyrifos*, **H** cyfluthrin, **H** deltamethrin, diflubenzuron, fluvalinate, **H** imidacloprid + clothianidin, indoxacarb, **H** lambda-cyhalothrin, **H** permethrin, **H** pyrethrins, **H** spinosad	Apply compounds at the first signs of feeding on newly opened leaves. **Cultural control.** Place sticky bands around the trunk of the tree to trap wingless females in October and fall cankerworms in November, and spring cankerworms in late March. Sticky bands may injure thin-barked trees.
Eastern tent caterpillar	*Malus, Prunus*	acephate, azadirachtin, **H** *Bacillus thuringiensis* var. *Kurstaki*, **H** bifenthrin, **H** carbaryl, chlorantraniliprole, chlorpyrifos*, **H** cyfluthrin, **H** deltamethrin, diflubenzuron, fluvalinate, **H** imidacloprid + clothianidin, indoxacarb, **H** lambda-cyhalothrin, malathion, methoxyfenozide, **H** permethrin, phosmet, **H** pyrethrins, **H** spinosad	Apply compounds at the first sign of webbing. Egg hatch occurs when *Magnolia x soulangiana* is in pink bud (50–100 GDD). **Cultural control.** Prune out and destroy egg masses during the dormant season.
Euonymus caterpillar	*Euonymus alata, Euonymus europaea*	**H** acephate, **H** Bacillus thuringiensis var. Kurstaki, **H** bifenthrin, **H** carbaryl, chlorantraniliprole, chlorpyrifos*, **H** deltamethrin, fluvalinate, **H** imidacloprid + clothianidin, indoxacarb, **H** lambda-cyhalothrin, **H** permethrin, **H** pyrethrins	Treat early in the season. *Euonymus europaea* is usually more severely defoliated than *E. alata*.

(continued)

Table 9. Insect pests and available control options *(continued)*

Insect	Host plants	Insecticide		Remarks
European pine shoot moth	*Pinus nigra,* **H** *Pinus resinosa,* **H** *Pinus sylvestris*	bifenthrin, carbaryl, chlorpyrifos*, **H** cyfluthrin, **H** deltamethrin,	diflubenzuron, malathion, **H** permethrin, phosmet, **H** pyrethrins	Apply first treatment in early May when *Magnolia x soulangiana* buds begin to show pink (50–100 GDD) and repeat when *Hydrangea arborescens* 'Grandiflora' is in early bloom (900–1000 GDD) to control larvae after egg hatch.
Fall webworm	*Betula, Carya,* **H** *Fraxinus, Juglans, Malus,* **H** *Populus, Prunus, Quercus, Salix,* **H** *Tilia, Ulmus*	acephate, azadirachtin, **H** *Bacillus thuringiensis* var. *Kurstaki*, **H** bifenthrin, chlorantraniliprole, chlorpyrifos*, **H** cyfluthrin, **H** deltamethrin, diflubenzuron,	fluvalinate, **H** imidacloprid + clothianidin, indoxacarb, **H** lambda-cyhalothrin, methoxyfenozide, **H** permethrin, **H** pyrethrins, **H** spinosad	Spot treat in late July and August at signs of activity. **Cultural control.** Destroy nests.
Gypsy moth	numerous hosts **H** **H** **H** **H** **H** **H**	acephate, azadirachtin, *Bacillus thuringiensis* var. *Kurstaki,* bidrin, bifenthrin, carbaryl, chlorantraniliprole, chlorpyrifos*, cryolite, cyfluthrin, cypermethrin,	**H** deltamethrin, diflubenzuron, fluvalinate, **H** imidacloprid + clothianidin, indoxacarb, **H** insecticidal soap, malathion, methoxyfenozide, **H** permethrin, phosmet, **H** pyrethrin, **H** spinosad	Treat early instar larvae in May when *Magnolia x soulangiana* is dropping petals. Best control is achieved through an integrated system that includes chemical and biological insecticides and growth regulators.
Spiny elm caterpillar	*Salix, Ulmus* **H** **H** **H** **H** **H**	*Bacillus thuringiensis,* bifenthrin, carbaryl, chlorantraniliprole, chlorpyrifos*, cyfluthrin, deltamethrin,	diflubenzuron, fluvalinate, **H** imidacloprid + clothianidin, indoxacarb, **H** lambda-cyhalothrin, **H** permethrin, **H** pyrethrins	Treat in June and July.
Walnut caterpillar	*Carya, Juglans* **H** **H** **H** **H** **H**	*Bacillus thuringiensis* var. *Kurstaki,* bifenthrin, carbaryl, chlorantraniliprole, chlorpyrifos*, cyfluthrin,	**H** deltamethrin, fluvalinate, **H** imidacloprid + clothianidin, indoxacarb, **H** lambda-cyhalothrin, **H** permethrin, **H** pyrethrins	Treat at first sign of activity in late July or early August. **Cultural control.** Prune out and destroy egg masses during the dormant season.

(continued)

Table 9. Insect pests and available control options *(continued)*

Insect	Host plants	Insecticide	Remarks
White-marked tussock moth	*Abies, Acer, Betula, Juglans, Malus, Pseudotsuga, Tilia*	**H** acephate, **H** *Bacillus thuringiensis*, **H** bifenthrin, chlorantraniliprole, **H** cyfluthrin, diflubenzuron, fluvalinate, indoxacarb, **H** lambda-cyhalothrin, methoxyfenozide, **H** spinosad	Treat immature larvae when *Philadelphus* is in bloom (500–600 GDD) in late May. Treat second generation in mid- to late summer when *Solidago* is in early bloom (1800–2100 GDD). **Cultural control.** Destroy egg masses found on trunks.
Yellow-necked caterpillar	*Acer, Crataegus, Juglans, Malus, Prunus, Quercus, Ulmus*	**H** acephate, **H** *Bacillus thuringiensis* var. *Kurstaki*, **H** bifenthrin, chlorantraniliprole, chlorpyrifos*, **H** cyfluthrin, **H** deltamethrin, fluvalinate, **H** imidacloprid + clothianidin, indoxacarb, **H** lambda-cyhalothrin, methoxyfenozide, **H** permethrin, **H** pyrethrins, **H** spinosad	Apply treatment during early larval development for most effective control.
Zimmerman pine moth complex	*Pinus*	**H** bifenthrin, chlorpyrifos*, **H** deltamethrin, diflubenzuron, methoxyfenozide, **H** permethrin	Apply in spring at 25DD before *Magnolia x soulangiana* is in pink bud.
Gall-formers			
Balsam gall midge	*Abies*	**H** bifenthrin, chlorpyrifos*, **H** deltamethrin	Apply to foliage in early to mid-May. Control not practical after mid-June. Treat when new shoots are 1.5 inches long. May be difficult to control.
Hackberry nipple gall	*Celtis*	**H** bifenthrin, **H** carbaryl, **H** deltamethrin, **H** imidacloprid, **H** imidacloprid + clothianidin, thiamethoxam	Treat all bark surfaces with carbaryl in early May. Repeat in late May if necessary. May be very difficult to control. Apply imidacloprid as a soil injection or drench in the fall. Spring applications should be made foliarly.
Hickory leaf stem gall aphid	*Carya*	**H** acephate, clothianidin, **H** deltamethrin, **H** imidacloprid, **H** imidacloprid + clothianidin, thiamethoxam	Treat with acephate just before foliage develops in spring. Timing may be difficult. Apply clothianidin, imidacloprid, or thiamethoxam as a soil injection or drench in the fall. Spring applications should be made foliarly.
Honeylocust pod gall midge	*Gleditsia triacanthos*	**H** acephate, **H** bifenthrin, **H** deltamethrin, thiamethoxam	Treat in mid-May soon after honeylocust is breaking bud (100–200 GDD). Repeat every 7–10 days.
Oak leaf gall	*Quercus*	**H** acephate, **H** bifenthrin, **H** deltamethrin	Treatment is not necessary. If used, apply as leaves are expanding. **Cultural control.** Rake and destroy fallen leaves.

(continued)

Table 9. Insect pests and available control options *(continued)*

Insect	Host plants	Insecticide	Remarks
Spruce gall adelgid (Cooley & Eastern)	*Picea, Pseudotsuga*	**H** bifenthrin, **H** chlorpyrifos*, **H** deltamethrin, **H** imidacloprid, **H** imidacloprid + clothianidin, **H** insecticidal soap, thiamethoxam	Apply when *Magnolia x soulangiana* is in pink bud (50–100 GDD). Apply imidacloprid as a soil injection or drench in the fall. Spring applications should be made foliarly. **Cultural control.** Prune galls when green if only a few are present.
Leafhoppers			
Leafhoppers	*Acer, Gleditsia triacanthos*	**H** acephate, **H** azadirachtin, **H** bifenthrin, bifenthrin + clothianidin, **H** carbaryl, chlorpyrifos*, clothianidin, **H** cyfluthrin, **H** deltamethrin, **H** dinotefuran, fenpropathrin, fluvalinate, **H** imidacloprid, **H** imidacloprid + clothianidin, **H** insecticidal soap, **H** lambda-cyhalothrin, malathion, permethrin, phosmet, **H** pyrethrins, thiamethoxam	Begin treatment at the first signs of feeding. Activity begins in early June. Apply azadirachtin early in the morning or late in the day. Apply clothianidin, dinotefuran, imidacloprid, or thiamethoxam as a soil injection or drench in the fall. Spring applications should be made foliarly.
Leafminers and skeletonizers			
Arborvitae leafminer	*Thuja*	**H** acephate, **H** bifenthrin, bifenthrin + clothianidin, clothianidin, **H** deltamethrin, dinotefuran, **H** imidacloprid, **H** imidacloprid + clothianidin, **H** permethrin, **H** pyrethrins, thiamethoxam	Apply foliar insecticides in early May and repeat again in mid-June. Apply clothianidin, dinotefuran, imidacloprid, or thiamethoxam as a soil injection or drench in the fall. Spring applications should be made foliarly. **Cultural control.** Remove and destroy infested tips by mid-May.
Birch leafminer	Betula	**H** acephate, **H** bifenthrin, bifenthrin + clothianidin, **H** carbaryl, chlorpyrifos*, chlorantraniliprole, clothianidin, **H** deltamethrin, dinotefuran, **H** imidacloprid, **H** imidacloprid + clothianidin, malathion, **H** permethrin, phosmet, **H** pyrethrins, thiamethoxam	Make first foliar application when leaves are half expanded or at the first sign of leaf blisters. Apply clothianidin, dinotefuran, imidacloprid, or thiamethoxam as a soil injection or drench in the fall. Spring applications should be made foliarly.
Birch leaf skeletonizer	*Betula*	**H** acephate, **H** carbaryl, cyfluthrin, **H** deltamethrin, **H** lambda-cyhalothrin	Apply in late July to August.

(continued)

Table 9. Insect pests and available control options *(continued)*

Insect	Host plants	Insecticide		Remarks
Cherry-hawthorn leafminer	*Crataegus, Prunus*	**H** acephate, **H** bifenthrin + clothianidin, **H** carbaryl, clothianidin, **H** deltamethrin, dinotefuran,	**H** imidacloprid, **H** imidacloprid + clothianidin, malathion, **H** permethrin, **H** pyrethrins, thiamethoxam	Make first foliar application when leaves begin to expand. Apply clothianidin, dinotefuran, imidacloprid, or thiamethoxam as a soil injection or drench in the fall. Spring applications should be made foliarly.
Elm leafminer	*Ulmus*	**H** acephate, **H** azadirachtin, bifenthrin + clothianidin, **H** carbaryl, chlorantraniliprole, chlorpyrifos*,	clothianidin, **H** deltamethrin, dinotefuran, **H** imidacloprid, **H** imidacloprid + clothianidin, **H** permethrin, **H** pyrethrins, thiamethoxam	Treat foliage at the first sign of activity. Apply clothianidin, dinotefuran, imidacloprid, or thiamethoxam as a soil injection or drench in the fall. Spring applications should be made foliarly.
Oak leafminer	*Quercus*	**H** carbaryl, clothianidin, **H** deltamethrin, dinotefuran, **H** imidacloprid, **H** imidacloprid + clothianidin, thiamethoxam		Treat foliage when leaves are expanding or at first sign of activity. Apply clothianidin, dinotefuran, imidacloprid, or thiamethoxam as a soil injection or drench in the fall. Spring applications should be made foliarly. **Cultural control.** Remove and destroy nests.
Oak leaf skeletonizer	Quercus	**H** *Bacillus thuringiensis* var. *Kurstaki*, **H** carbaryl, chlorpyrifos*, clothianidin,	**H** deltamethrin, dinotefuran, **H** imidacloprid, **H** lambda-cyhalothrin, thiamethoxam	Treat foliage in late June and mid-August at the first sign of activity. Apply clothianidin, dinotefuran, imidacloprid, or thiamethoxam as a soil injection or drench in the fall. Spring applications should be made foliarly.
Pine needle miner	*Pinus*	**H** acephate, clothianidin, **H** deltamethrin,	**H** imidacloprid, thiamethoxam	Treat foliage in early June. Apply clothianidin, imidacloprid, or thiamethoxam as a soil injection or drench in the fall. Spring applications should be made foliarly.
Spruce needle miner	*Picea*	**H** acephate, **H** carbaryl, chlorpyrifos*, clothianidin, **H** deltamethrin,	**H** imidacloprid, thiamethoxam	Treat larvae when *Magnolia x soulangiana* is in full bloom (100–200 GDD). Apply clothianidin, imidacloprid, or thiamethoxam as a soil injection or drench in the fall. Spring applications should be made foliarly.
Mites				
Ash flower gall mite	*Fraxinus*	abamectin, **H** bifenthrin, **H** carbaryl,	**H** deltamethrin, **H** ultra-fine oil	Apply as leaves are just beginning to unfurl. **Cultural control.** Prune new galls out by July 1.
Eriophyid mite		abamectin, **H** carbaryl, **H** deltamethrin,	**H** insecticidal soap, **H** ultra-fine oil	Mites overwinter on bud scales. Apply insecticides as new leaves or needles develop in the spring.

(continued)

Table 9. Insect pests and available control options *(continued)*

Insect	Host plants	Insecticide	Remarks
Honeylocust mite	*Gleditsia triacanthos*	abamectin, **H** deltamethrin, **H** lambda-cyhalothrin, **H** 2% oil	Apply early in spring at time of budbreak to control mites, plantbugs, and leafhoppers.
Maple gall mite	*Acer*	abamectin, **H** carbaryl, **H** deltamethrin	Treat when leaves are half expanded in spring.
Spider mites	Numerous hosts	abamectin, acequinocyl, azadirachtin, **H** bifenthrin, chlorpyrifos*, **H** deltamethrin, **H** dormant oil, etoxazole, fenpropathrin, fluvalinate, hexythiazox, **H** insecticidal soap, **H** lambda-cyhalothrin, **H** spinosad, **H** sulfur, **H** ultra-fine oil	Apply in mid- to late summer when *Hydrangea arborescens* 'Grandiflora' is in early bloom (900–1000 GDD). Repeat applications at 7- to 10-day intervals. Hot, dry conditions favor the buildup of mite populations.
Spruce spider mite	*Picea, Thuja*	abamectin, **H** acephate, acequinocyl, **H** bifenthrin, chlorpyrifos*, **H** deltamethrin, **H** dormant oil, etoxazole, hexythiazox, **H** insecticidal soap, **H** lambda-cyhalothrin, malathion, **H** spinosad, **H** ultra-fine oil	Apply in early June. If treatment isn't made until early July, a second application 10–14 days later may be necessary.
Plantbugs			
Ash plantbug	*Fraxinus*	**H** acephate, **H** bifenthrin, **H** carbaryl, chlorpyrifos*, **H** cyfluthrin, **H** deltamethrin, fluvalinate, **H** insecticidal soap, **H** lambda-cyhalothrin, malathion, **H** permethrin, **H** pyrethrin, resmethrin, thiamethoxam, **H** ultra-fine oil	Make initial application at bud break in May or as needed.
Honeylocust plantbug	*Gleditsia triacanthos*	**H** acephate, **H** bifenthrin, **H** carbaryl, chlorpyrifos*, **H** cyfluthrin, **H** deltamethrin, fluvalinate, **H** insecticidal soap, **H** lambda-cyhalothrin, malathion, **H** permethrin, resmethrin, thiamethoxam, **H** ultra-fine oil	Apply soon after budbreak.

(continued)

Table 9. Insect pests and available control options *(continued)*

Insect	Host plants	Insecticide	Remarks
Lace bugs	*Crataegus, Quercus, Sorbus*	**H** acephate, **H** bifenthrin, **H** carbaryl, **H** chlorantraniliprole, **H** chlorpyrifos*, **H** cyfluthrin, **H** deltamethrin, **H** dinotefuran, **H** fenpropathrin, **H** imidacloprid, **H** imidacloprid + clothianidin, **H** insecticidal soap, **H** lambda-cyhalothrin, **H** malathion, **H** permethrin, **H** pyrethrins, **H** thiamethoxam, **H** ultra-fine oil	Examine undersides of leaves for insects. Fully treat lower leaf surfaces. Apply imidacloprid or thiamethoxam as a soil injection or drench in the fall. Spring applications should be made foliarly. **Cultural control.** Pressurized water may dislodge nymphs.
Sawflies			
Elm sawfly	*Salix, Ulmus*	**H** acephate, **H** azadirachtin, **H** bifenthrin, **H** carbaryl, **H** chlorpyrifos*, **H** cyfluthrin, **H** deltamethrin, **H** diflubenzuron, **H** imidacloprid, **H** imidacloprid + clothianidin, **H** insecticidal soap, **H** lambda-cyhalothrin, **H** malathion, **H** pyrethrin, **H** thiamethoxam, **H** ultra-fine oil	Treat the foliage of infested trees in June or July. Apply imidacloprid or thiamethoxam as a soil injection or drench in the fall. Spring applications should be made foliarly.
European pine sawfly	*Pinus*	**H** acephate, **H** azadirachtin, **H** bidrin, **H** bifenthrin, **H** carbaryl, **H** chlorpyrifos*, **H** cyfluthrin, **H** deltamethrin, **H** diflubenzuron, esfenvalerate, **H** imidacloprid, **H** imidacloprid + clothianidin, **H** indoxacarb, **H** lambda-cyhalothrin, **H** malathion, **H** spinosad, **H** thiamethoxam	Make foliar applications in spring when *Magnolia x soulangiana* is dropping petals (100–200GDD). Apply imidacloprid or thiamethoxam as a soil injection or drench in the fall. Spring applications should be made foliarly. **Cultural control.** Small numbers of larvae can be removed by hand.
Imported pine sawfly	*Pinus*	**H** acephate, **H** bifenthrin, **H** carbaryl, **H** chlorpyrifos*, **H** clothianidin, **H** cyfluthrin, diflubenzuron, **H** imidacloprid, **H** imidacloprid + clothianidin, **H** lambda-cyhalothrin, malathion, thiamethoxam	Treat foliage in spring when *Magnolia x soulangiana* is dropping petals (100–200 GDD). Apply clothianidin, imidacloprid, or thiamethoxam as a soil injection or drench in the fall. Spring applications should be made foliarly. **Cultural control.** Remove minor infestations by hand.
Mountain-ash sawfly	*Sorbus aucuparia*	**H** bifenthrin, **H** carbaryl, clothianidin, **H** cyfluthrin, **H** deltamethrin, diflubenzuron, **H** deltamethrin, **H** imidacloprid, **H** imidacloprid + clothianidin, **H** lambda-cyhalothrin, malathion, thiamethoxam	Treat at first sign of foliar injury, usually mid-June. Apply clothianidin, imidacloprid, or thiamethoxam as a soil injection or drench in the fall. Spring applications should be made foliarly. **Cultural control.** Destroy colonies.

(continued)

Table 9. Insect pests and available control options *(continued)*

Insect	Host plants	Insecticide	Remarks
Redheaded pine sawfly	*Pinus*	**H** acephate, azadirachtin, **H** bifenthrin, **H** carbaryl, chlorpyrifos*, clothianidin, **H** cyfluthrin, **H** deltamethrin, diflubenzuron, esfenvalerate, imidacloprid, **H** imidacloprid + clothianidin, **H** lambda-cyhalothrin, malathion, **H** spinosad	Treat foliage at first sign of activity in mid-June. Apply clothianidin or imidacloprid as a soil injection or drench in the fall. Spring applications should be made foliarly. **Cultural control.** Remove minor infestations by hand.
Viburnum shoot sawfly	*Viburnum*	**H** acephate, **H** bifenthrin, **H** carbaryl, chlorpyrifos*, cyfluthrin, **H** deltamethrin, diflubenzuron, **H** imidacloprid, **H** imidacloprid + clothianidin, **H** lambda-cyhalothrin, malathion	**Cultural control.** Prune out and destroy affected shoots if infestation is small.
Scales			
Cottony maple scale	*Acer, Rhus*	**H** acephate, **H** carbaryl, chlorpyrifos*, clothianidin, **H** cyfluthrin, **H** deltamethrin, dinotefuran, **H** dormant oil, **H** imidacloprid, **H** imidacloprid + clothianidin, **H** insecticidal soap, **H** lambda-cyhalothrin, **H** permethrin, **H** pyrethrins, **H** rotenone, thiamethoxam, **H** ultra-fine oil	Treat when crawlers are active—about the first week in July when *Hydrangea arborescens* 'Grandiflora' is in early bloom (900–1000 GDD). Apply clothianidin, dinotefuran, imidacloprid, or thiamethoxam as a soil injection or drench in the fall. Spring applications should be made foliarly. **Cultural control.** Hand prune and destroy small infestations.
Euonymus scale	Euonymus	**H** acephate, chlorpyrifos*, clothianidin, **H** cyfluthrin, **H** deltamethrin, dinotefuran, **H** imidacloprid, **H** imidacloprid + clothianidin, **H** insecticidal soap, **H** lambda-cyhalothrin, malathion, **H** permethrin, **H** pyrethrins, **H** rotenone, thiamethoxam, **H** ultra-fine oil	Make first treatment in early June when *Syringa reticulata* is in early bloom (500–700 GDD). Repeat twice at 10- to 12-day intervals for a total of 3 applications. Apply clothianidin, dinotefuran, imidacloprid, or thiamethoxam as a soil injection or drench in the fall. Spring applications should be made foliarly.
Juniper scale	*Juniperus*	**H** acephate, clothianidin, **H** cyfluthrin, **H** deltamethrin, dinotefuran, **H** dormant oil, **H** imidacloprid, **H** imidacloprid + clothianidin, **H** lambda-cyhalothrin, malathion, **H** permethrin, **H** pyrethrins, thiamethoxam, **H** ultra-fine oil	Treat in early July when crawlers are active. Apply clothianidin, dinotefuran, imidacloprid, or thiamethoxam as a soil injection or drench in the fall. Spring applications should be made foliarly.

(continued)

Table 9. Insect pests and available control options *(continued)*

Insect	Host plants	Insecticide		Remarks
Lecanium scale	*Acer, Berberis, Betula, Celtis, Crataegus, Euonymus, Gleditsia, Malus, Prunus, Quercus, Salix, Thuja, Tilia*	**H** acephate, **H** carbaryl, chlorpyrifos*, clothianidin, **H** cyfluthrin, **H** deltamethrin, dinotefuran, **H** imidacloprid, **H** imidacloprid + clothianidin, **H** lambda-cyhalothrin, lime sulfur, **H** permethrin, **H** pyrethrins, thiamethoxam, **H** ultra-fine oil		Treat crawlers when *Hydrangea arborescens* 'Grandiflora' is in full bloom (900–1200 GDD); make a second application 2 weeks later. Apply clothianidin, dinotefuran, imidacloprid, or thiamethoxam as a soil injection or drench in the fall. Spring applications should be made foliarly. Apply lime sulfur during dormant season only.
Magnolia scale	*Magnolia*	**H** acephate, **H** azadirachtin, **H** bifenthrin, **H** carbaryl, chlorpyrifos*, **H** cyfluthrin, **H** deltamethrin, **H** dinotefuran, **H** horticultural oils, **H** imidacloprid, **H** imidacloprid + clothianidin, **H** insecticidal soap, **H** lambda-cyhalothrin, malathion, **H** permethrin, **H** pyrethrins, thiamethoxam		Treat crawlers with horticultural oils or insecticidal soaps in August and September. Dormant oils can be used in late fall and early spring to reduce nymph populations. Apply dinotefuran, imidacloprid, or thiamethoxam as a soil injection or drench in the fall. Spring applications should be made foliarly. **Cultural control.** Hand prune and destroy small infestations.
Oystershell scale	*Acer, Cornus, Corylus, Cotoneaster, Fraxinus, Juglans, Malus, Prunus, Salix, Syringa*	**H** acephate, chlorpyrifos*, clothianidin, **H** cyfluthrin, **H** deltamethrin, dinotefuran, **H** imidacloprid, **H** imidacloprid + clothianidin, **H** lambda-cyhalothrin, malathion, **H** permethrin, **H** pyrethrins, thiamethoxam, **H** ultra-fine oil		Treat crawlers when *Spiraea x vanhouttei* is in full to late bloom (275–500 GDD). To control a second generation, treat when *Hydrangea arborescens* 'Grandiflora' blossoms turn from white to green (1600–1700 GDD). Apply clothianidin, dinotefuran, imidacloprid, or thiamethoxam as a soil injection or drench in the fall. Spring applications should be made foliarly.
Pine needle scale	*Pinus*	**H** bifenthrin, chlorpyrifos*, clothianidin, **H** cyfluthrin, **H** deltamethrin, dinotefuran, **H** imidacloprid, **H** imidacloprid + clothianidin, **H** insecticidal soap, **H** lambda-cyhalothrin, lime sulfur, malathion, **H** pyrethrins, thiamethoxam, **H** ultra-fine oil		Treat the first generation of crawlers when *Spiraea x vanhouttei* is in full to late bloom (275–500 GDD). To control a second generation, treat when *Hydrangea arborescens* 'Grandiflora' blossoms turn from white to green (1600–1700 GDD). Repeat at least once in 7–10 days. Apply clothianidin, dinotefuran, imidacloprid, or thiamethoxam as a soil injection or drench in the fall. Spring applications should be made foliarly. Apply lime sulfur during dormant season only.

(continued)

Table 9. Insect pests and available control options *(continued)*

Insect	Host plants	Insecticide	Remarks
Pine tortoise scale	*Pinus*	chlorpyrifos*, clothianidin, **H** cyfluthrin, **H** deltamethrin, dinotefuran, **H** imidacloprid, **H** imidacloprid + clothianidin, **H** insecticidal soap, **H** pyrethrins, thiamethoxam, **H** ultra-fine oil	Treat in mid-June when crawlers are active. Apply clothianidin, dinotefuran, imidacloprid, or thiamethoxam as a soil injection or drench in the fall. Spring applications should be made foliarly.
San Jose scale	*Cornus, Cotoneaster, Crataegus, Forsythia, Ligustrum, Malus, Prunus, Rosa, Sorbus, Tilia*	**H** bifenthrin, chlorpyrifos*, clothianidin, **H** cyfluthrin, **H** deltamethrin, dinotefuran, fenpropathrin, **H** imidacloprid, **H** imidacloprid + clothianidin, **H** lambda-cyhalothrin, lime sulfur, **H** pyrethrins, thiamethoxam, **H** ultra-fine oil	Control crawlers when *Syringa reticulata* is in full bloom (800–900 GDD). Repeat at 7- to 10-day intervals. Apply clothianidin, dinotefuran, imidacloprid, or thiamethoxam as a soil injection or drench in the fall. Spring applications should be made foliarly. Apply lime sulfur during dormant season only.
Weevils			
Black vine weevil	*Euonymus, Taxus*	**H** acephate, **H** bifenthrin, bifenthrin + clothianidin, chlorpyrifos*, clothianidin, **H** deltamethrin, **H** dinotefuran, fluvalinate, **H** imidacloprid, **H** imidacloprid + clothianidin, **H** lambda-cyhalothrin, **H** permethrin, thiamethoxam	Apply to foliage 2–3 times beginning in early June when adult weevils are present. Apply clothianidin, imidacloprid, or thiamethoxam as a soil injection or drench in the fall. Spring applications should be made foliarly.
White pine weevil	*Abies, Picea, Pinus*	**H** bifenthrin, **H** deltamethrin, diflubenzuron	Spray leaders early in May. Temperatures must be above 50°F. **Cultural control.** Remove and destroy wilted leaders.
Other insects			
Larch casebearer	*Larix*	**H** acephate, **H** bifenthrin, **H** carbaryl, **H** deltamethrin, **H** imidacloprid + clothianidin, lime sulfur	Treat as new needles develop. Apply lime sulfur during dormant season only.
Privet thrips	*Ligustrum*	**H** acephate, **H** carbaryl, chlorpyrifos*, **H** cyfluthrin, dinotefuran, **H** imidacloprid + clothianidin, **H** spinosad	Apply at the first sign of infestation. Leaves will become silvery in color from heavy infestations.
Taxus mealybug	*Taxus*	**H** acephate, **H** bifenthrin, **H** carbaryl, chlorpyrifos*, **H** cyfluthrin, **H** deltamethrin, dinotefuran, fenpropathrin, **H** imidacloprid, **H** imidacloprid + clothianidin, **H** insecticidal soap, malathion, **H** pyrethrins, thiamethoxam	Treat nymphs when *Spiraea x vanhouttei* is in full bloom (200–300 GDD). Apply thoroughly.

H = Formulations of this active ingredient intended for homeowner use are available.
* = Chlorpyrifos is restricted to production nurseries only.

WEED MANAGEMENT

An effective weed management program should integrate chemical, cultural, and mechanical methods. Make weed management a part of the overall nursery management plan. Nursery weed control should begin the year before planting. Infestations of perennial weeds such as quackgrass and Canada thistle should be controlled by nonresidual herbicides and timely cultivation a full season before planting.

Weed control in nurseries is most important in the planting row. Weed growth between the rows can be reduced by establishing a sod-forming cover crop such as perennial rye, red fescue, or dwarf white clover. Keep a 2-foot band free of vegetation around the trees. Weeds growing close to trees compete for water and nutrients and can slow stock development. Weed growth immediately around the trunks creates a habitat for rodents which can damage trees during the dormant season.

Chemicals are not a substitute for good management. Using the correct herbicide properly on the right species helps make an effective weed management program. Plan your program early, take advantage of mechanical means of weed management, and fit necessary herbicide applications into the overall schedule. Don't use the same herbicides every year to control weeds. Rotate among several herbicides to avoid the development of herbicide-resistant weeds.

Herbicides are registered for use on specific plants. This information is given on the label. Herbicide effectiveness depends on (1) proper application, (2) application rate, (3) temperature, (4) moisture, (5) soil type, (6) weed species, and (7) geographic location. Read the product label to make sure you apply each product legally!

CALCULATION FOR BAND APPLICATION

Band applications are more economical than broadcast treatments. For band applications or spot application around trees, the amount of herbicide and water must be reduced in proportion to the area actually sprayed. To make the calculations, you need the following five facts:

1. Width of treated band
2. Distance between rows
3. Acres of nursery
4. Broadcast rate of herbicide
5. Output of sprayer

Use the following equations to calculate the number of acres actually treated.

$$\frac{\text{Width of treated band (1)} \times \text{Acres of nursery (3)}}{\text{Distance between rows (2)}} = \text{Acres actually treated}$$

Acres actually treated x Broadcast rate of herbicide (4) = Amount of herbicide needed

Acres actually treated x Output of sprayer (5) = Amount of water needed

References to herbicides in this publication are for your convenience and are not an endorsement of one product or manufacturer over another. In some situations, the efficacy and phytotoxic effects of these products have not been tested and results may vary. Please refer to the product label for specific rates and application instructions as well as other site and use restrictions and precautions.

Table 10. HERBICIDES—Common names, trade names, and safety information

Common names	Trade names	Manufacturer	Signal word	Notification	Mode of action	REI (hours)	Oral LD_{50}	Dermal LD_{50}
alachlor	various	Monsanto	caution-danger	either	shoot growth inhibitor	12	2,000	7,800
bentazon	Basagran T/O	BASF	caution	either	photosynthesis inhibitor	48	>200	>2,000
clethodim	Envoy	Valent	caution	either	lipid synthesis inhibitor	24	4,900	>5,000
DCPA	Dacthal	Amvac	caution	either	root growth inhibitor	12	3,000	>10,000
dichlobenil	Casoron	Chemtura	caution	either	cell wall synthesis inhibitor	12	5,000	1,350
fluazifop-P-butyl	Fusilade II, Ornamec	Syngenta, Gordon's	caution	either	ACC inhibitor	12	>5,000	>2,000
flumioxazin	BroadStar, SureGuard	Valent	caution	either	cell membrane disruptor	12	>5,000	>2,000
glufosinate-ammonium	Finale	Bayer	warning	either	glutamine synthesis inhibitor	12	3,570	>2,000
glyphosate	several	several	caution-warning	either	amino acid synthesis inhibitor	varies	5,000	>5,000
isoxaben	Gallery	Dow AgroSciences	caution	either	cell wall synthesis inhibitor	12	5,000	5,000
isoxaben + trifluralin	Snapshot	Dow AgroSciences	caution	either	cell wall synthesis and root growth inhibitor	12	>5,000	>2,500
isoxaben + trifluralin + oxyfluorfen	Showcase	Dow AgroSciences	caution	either	cell wall synthesis, root growth, and PPO inhibitor	24	>5,000	>2,500
oryzalin	Surflan	UPI	caution	either	root growth inhibitor	24[a]	5,000	>5,000
oxadiazon	Ronstar	Bayer	warning	either	PPO inhibitor	12	>5,000	>10,000
oxyfluorfen	Goal, Galigan	Dow AgroSciences, MANA	caution-warning	either	PPO inhibitor	24[a]	2,000	>2,999
pendimethalin	Pendulum	BASF	caution	either	root growth inhibitor	24	3,956	2,200
prodiamine	Barricade	Syngenta	caution	either	root growth inhibitor	12	>5,000	>2,000
pronamide	Kerb	Dow AgroSciences	caution	either	root growth inhibitor	24	>5,000	>2,000
simazine	Princep, Drexel Simazine	Syngenta, Drexel	caution	either	photosynthesis inhibitor	12	>5,000	>2,500
s-metolachlor	Pennant Magnum	Syngenta	caution	either	shoot growth inhibitor	24	3,750	>2,010

[a] REI may vary in certain situations. Consult label.

Table 11. Herbicide effectiveness on weeds commonly found in nurseries (descriptions of herbicides follow tables)

	alachlor	bentazon	clethodim	DCPA	dichlobenil	fluazifop-P- butyl	flumioxazin	glufosinate ammonium	glyphosate	isoxaben	isoxaben + trifluralin	isoxaben+trifluralin +oxyfluorfen	s-metolachlor	oryzalin	oxadiazon	oxyfluorfen	pendimethalin	prodiamine	pronamide	simazine
Broadleaves																				
carrot, wild	—	—	N	—	G	N	—	—	—	G	G	G	—	P	—	—	—	—	—	P
chickweed	—	—	N	G	G	N	G	G	G	G	G	G	F	G	—	F	G	G	G	G
clover	—	—	N	—	—	N	—	G	G	G	G	G	—	P	—	G	P	—	G	F
cocklebur	P	—	N	—	—	N	—	G	G	—	—	—	—	—	—	G	—	—	—	F
eastern black nightshade	G	—	N	G	—	N	G	G	F	G	G	G	F	—	—	G	—	—	G	G
evening primrose	—	—	N	—	G	N	—	—	G	F	G	G	F	G	F	F	G	—	—	G
jimsonweed	P	—	N	—	—	N	G	G	G	G	G	G	P	P	—	G	P	—	P	G
knotweed	F	—	N	G	G	N	—	—	G	G	G	G	G	G	—	G	G	—	G	F
lambsquarters, common	F	F	N	—	G	N	G	G	G	G	G	G	F	G	G	G	G	G	G	G
marestail	—	—	N	—	—	N	G*	G	G	G	G	G	F	G	—	—	P	—	—	F
morning glory	P	—	N	—	—	N	G	—	G	F	G	G	F	F	—	G	F	—	G	F
mustard, wild	P	G	N	—	G	N	G	G	G	G	G	G	P	F	—	G	—	—	G	G
pigweed, redroot	G	N	N	—	G	N	G	G	G	G	G	G	G	G	G	G	G	G	—	G
plantain	—	N	N	—	G	N	G*	—	—	G	G	G	G	G	—	—	—	—	—	F
purslane	F	G	N	—	G	N	G	G	G	G	G	G	F	G	G	G	G	G	G	G
ragweed, common	P	F	N	—	G	N	G	G	G	G	G	G	F	F	—	F	P	—	G	G
smartweed	P	G	N	—	G	N	G	G	F	G	G	G	P	F	G	G	G	—	—	G
velvetleaf	P	—	N	—	—	N	G	G	G	G	G	G	G	F	—	G	G	—	F	F
Grasses																				
barnyardgrass	G	—	G	—	—	G	G*	G	G	—	G	G	G	G	F	G	G	G	G	G
brome, downy	—	—	G	—	—	—	—	—	G	—	—	—	—	G	—	—	—	—	G	G
crabgrass	G	—	G	—	G	G	G*	G	F	—	G	G	G	G	G	F	G	G	G	G
fescue, tall	—	—	—	—	—	—	—	G	G	—	P	P	—	P	—	—	N	—	G	P
foxtail, giant	G	—	G	G	G	G	G*	G	G	—	G	G	G	G	—	G	G	G	—	G
foxtail, green/yellow	G	—	G	G	G	G	G*	G	G	—	G	G	G	G	G	—	G	G	G	G
johnsongrass	P	—	G	G	—	G	—	G	G	—	F	F	F	G	—	—	G	G	P	P
panicum, fall	G	—	G	—	—	G	G*	G	G	—	G	G	G	G	G	F	G	G	G	G
sandbur	F	—	G	G	—	G	—	G	G	—	G	G	F	G	—	—	G	—	—	P
wild proso millet	F	—	G	—	—	G	—	—	G	—	—	—	F	—	—	—	F	—	—	P
woolly cupgrass	F	—	G	—	—	G	—	G	F	—	—	—	F	—	—	—	G	G	—	P
Perennials																				
dandelion	—	N	N	—	G	N	G*	F	G	G	G	G	P	G	—	—	P	—	—	F
nutsedge, yellow	G	G	N	—	G	N	—	—	F	—	P	G	G	P	—	—	P	—	P	P
poison ivy	—	—	N	—	—	N	—	G	G	—	—	—	—	—	—	—	—	—	—	—
quackgrass	N	—	G	—	G	G	—	G	G	—	—	—	—	P	—	—	P	—	G	F
thistle, Canada	N	G	N	—	G	N	G*	G	G	—	—	—	—	—	—	—	—	—	—	P
vetch	—	—	N	—	—	N	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Ratings abbreviations: G = good, F = fair, P = poor, N = none, — = insufficient data.

*Preemergence control only.

DESCRIPTION OF HERBICIDES

Note: Ornamental plant tolerance varies reatly by species and even by variety within a species. Tolerant plants are listed on each herbicide label. Be sure to carefully read the label prior to any use. If using an herbicide for the first time on a listed tolerant species, consider trying it on a small scale to minimize potential injury risk.

Unless otherwise allowed on the product label, these herbicides are NOT for use in greenhouses, shadehouses, or other enclosed structures.

Table 12. Herbicide descriptions

Common name	Trade name	Uses and comments
alachlor	various	**Uses.** Restricted-use pesticide. For use as a directed spray on junipers and yews only. Primarily controls grass weeds and a few annual broadleaves and sedges. **Comments.** Do not allow contact with green foliage. Do not use on seedbeds, unrooted cuttings, or before transplanting. Do not apply through irrigation systems or mix with sprayable fluid fertilizers. Applications made when temperatures exceed 90°F may injure ornamentals. Delay cultivation after application for as long as possible. If weeds or grasses emerge, shallowly cultivate or rotary hoe without lateral soil movement to avoid diluting or displacing the herbicide.
bentazon	Basagran T/O	**Uses.** Postemergence control of certain broadleaf weeds and sedges, but not grasses. Bentazon is a contact herbicide, therefore thorough weed coverage is necessary. May be applied as a directed spray (avoid contact with desirable plants) around all ornamental and nursery plants except sycamore and rhododendron. Over-the-top applications are allowed for a few tolerant ornamentals—see the product label for a current list. **Comments.** Some leaf speckling and leaf bronzing may occur when relative humidity and temperatures are high. Crop oil concentrate will improve control of some weed species, but also increases the risk for ornamental injury—see the label for details. Early postemergence treatments to actively growing weeds will optimize control, with the exception of Canada thistle and yellow nutsedge.
clethodim	Envoy	**Uses.** Postemergence control of annual and perennial grass weeds. Does not control sedges. See the product label for tolerant ornamental species. **Comments.** Apply with an appropriate adjuvant (based on ornamental species—see product label) when grass weeds are actively growing and not under stress. Do not apply a postemergence broadleaf herbicide within 1 day following application or reduced grass control may result.
DCPA	Dacthal	**Uses.** Preemergent control of annual grasses and certain broadleaf weeds. Can be used with several ornamental species – see product label for current list. Do not use on bugleweed, button pink, carnation, geum, germander, mesembryanthemum, pansy, phlox, sweet William, or telanthera. **Comments.** Applications should be made to soil recently cultivated to a uniform texture. In established plantings, cultivate to remove existing weeds before application.

(continued)

Table 12. Herbicide descriptions *(continued)*

Common name	Trade name	Uses and comments
dichlobenil	Casoron	**Uses.** Preemergent control of annual and perennial broadleaf and grass weeds. Controls Canada thistle, quackgrass, wild carrot, fescue, and several other weeds prior to emergence. Can be used on some ornamental species – see product label for current list. **Comments.** Avoid applications which allow dichlobenil granules to lodge in the foliage, particularly in coniferous ornamentals, and don't allow granules to accumulate and be in contact with the trunk at or below the soil line. Thoroughly incorporate granules into the surface through watering-in. Wait 4 weeks after transplanting and 6 months after rooting of cuttings in the field, or after planting rooted cuttings. Do not use on light, sandy soils. Do not make surface application to areas cultivated the fall or summer before application.
fluazifop-P-butyl	Fusilade II, Ornamec	**Uses.** Postemergent control of annual and perennial grass weeds. Can be applied over the top of some woody ornamentals, but some ornamentals require directed sprays to minimize injury risk—see product label for current list and application method. **Comments.** Apply with a nonionic surfactant when grass weeds are actively growing. Do not use a crop oil concentrate.
flumioxazin	BroadStar	**Uses.** Preemergent granular herbicide that controls several annual broadleaf and grass weeds. See label for list of sensitive and tolerant ornamentals. **Comments.** Controls weeds for 8 to 12 weeks in field and in containerized plantings. Do not apply to containers less than 4 inches wide. Do not allow herbicide granules to rest on plant foliage after application. Do not apply to plants with wet foliage. Test tolerance of woody ornamental on a small scale before using. See label for other restrictions.
flumioxazin	SureGuard	**Uses.** Preemergent and postemergent control of several annual broadleaf and grass weeds in selected conifers and deciduous woody ornamentals. Application rate, timing, and placement are specific to the type of ornamental; see label for a list of ornamentals and instructions. **Comments.** Residual preemergent weed control can last 3 to 6 months. Use as a directed spray to the soil or potting media at the base of trees, without contacting ornamentals. Do not apply over the top of ornamentals. Directed applications after weed emergence can also control some weed species. See label for detailed instructions and restrictions.
glufosinate	Finale	**Uses.** Apply to emerged weeds as a directed spray around containers and field-grown established ornamentals. Glufosinate is a non-selective contact herbicide that will injure or kill most plant species. **Comments.** Do not apply directly to or allow drift to contact desirable green tissue or green, thin, uncalloused bark of desirable vegetation. Do not apply over the top of ornamentals.
glyphosate	Several trade names	**Uses.** Non-selective, translocated herbicide that controls most annual and perennial weeds after emergence. Applied as a directed-spray around established ornamentals. **Comments.** Avoid contact of spray, drift, or mist with desirable plant foliage or bark. Apply around only field-grown stock after weeds emerge. Not all products that contain the active ingredient glyphosate include ornamental uses, and even those that are labeled on ornamentals vary in formulation, additive requirements, and use instructions.

(continued)

Table 12. Herbicide descriptions *(continued)*

Common name	Trade name	Uses and comments
isoxaben	Gallery	**Uses.** Preemergent control of certain broadleaf weeds. The label contains a very specific list of sensitive and tolerant ornamental species. **Comments.** Do not apply to seedling beds, cutting beds, transplant beds, or pots less than 6 inches wide. Do not apply to unrooted liners or cuttings that have been planted in pots for the first time, or to bedding plants or areas where bedding plants will be planted or transplanted within 1 year after application. Do not apply to newly transplanted ornamentals or nursery stock until soil or potting media has been settled by packing and irrigation or rainfall and no cracks are present. Over-the-top applications to plants with newly forming buds may cause injury; instead, apply as a directed spray to the soil surface. When planting into a site treated in the past 8 months, use untreated soil as a fill around plant roots.
isoxaben + trifluralin	Snapshot	**Uses.** Preemergent control of certain broadleaf and annual grasses. Apply before weed germination or immediately after cultivation. The labels contain specific lists of sensitive and tolerant ornamental species. **Comments.** Do not apply to seedling beds, cutting beds, transplant beds, or pots less than 4 inches wide. Do not apply to unrooted liners or cuttings that have been planted in pots for the first time, or bedding plants or areas where bedding plants will be planted or transplanted within 1 year after application. Do not apply to newly transplanted ornamentals or nursery stock until soil or potting media has been settled by packing and irrigation or rainfall and no cracks are present. Where stand loss has occurred in field-grown ornamentals, use untreated soil as a fill around roots when replacing plants.
isoxaben + trifluralin + oxyfluorfen	Showcase	
oryzalin	Surflan	**Uses.** Preemergent residual control of annual grasses and many broadleaf weeds. Tolerant ornamentals are listed on the product label. DO NOT use on Deutzia gracilis (slender deutzia), Pseudotsuga menziesii (Douglas fir), Thuja occidentalis 'Techny' (Techny arborvitae), Tsuga canadensis (eastern hemlock), Begonia spp. (begonia), or Coleus hybridus (coleus). **Comments.** Will not control emerged weeds. Apply only to established plantings that have been transplanted into their growing location for a sufficient period of time to allow the soil to be firmly settled around the roots from packing and rainfall or irrigation. Do not apply to nursery, forest or Christmas tree seedling beds, cutting beds, or transplant beds, unrooted liners or cuttings that have been planted in pots for the first time, or pots less than 4 inches wide. Applications made over the top of plants with newly formed buds may cause injury. In this situation, use a directed spray. Do not apply to ornamental plantings where there is a likelihood of runoff into lawn areas. Rooted liners should be removed from their original growing containers and placed in new containers at least 2 weeks before treatment. For soils treated during the previous season, plant only ornamental species listed on the label. See label for additional restrictions.

(continued)

Table 12. Herbicide descriptions *(continued)*

Common name	Trade name	Uses and comments
oxadiazon	Ronstar	**Uses.** Preemergent control of several annual grass and broadleaf weeds. Apply as a directed application to the soil surface or as an over-the-top application ONLY on labeled species. See label for specific list of tolerant ornamentals. **Comments.** Do not apply during bud break or within 4 weeks after bud break. Rainfall or overhead irrigation after application will improve weed control. Rainfall or overhead irrigation immediately after over-the-top sprays is required to move oxadiazon from the foliage to the soil surface. Do not apply granules to wet foliage or under conditions in which granules will collect on leaves. Cultivating or disturbing soil after application may reduce weed control activity.
oxyfluorfen	Goal, Galigan	**Uses.** Preemergent and/or early postemergent control of selected annual grass and broadleaf weeds. Primarily used in selected coniferous ornamentals and as a directed spray in a few deciduous ornamentals. See label for tolerant species and application details. **Comments.** Preemergent weed control is most effective when spray is applied to weed-free soil surfaces. Treated soil surfaces should not be disturbed as the effectiveness of the herbicide may be decreased. In conifer transplants, apply only prior to bud break or after foliage has hardened off. For listed tolerant deciduous species, make directed applications to the soil around trees before buds swell in the spring or after trees have initiated dormancy in the fall. Avoid contact of spray drift or mist with foliage or green bark of deciduous trees. See label for additional use instructions.
pendimethalin	Pendulum	**Uses.** Preemergent control of selected annual and broadleaf weeds. Can be used with selected woody ornamentals listed on the product label. **Comments.** Application type (directed spray or over-the-top) and rate depend on ornamental species, type of nursery production, and plant age – see label for details. Weed control will improve when rainfall or overhead irrigation follow application. Plant only those species listed on the product label into soil treated the previous season with pendimethalin.
prodiamine	Barricade	**Uses.** Preemergent residual weed control of selected annual grass and broadleaf weeds. Can be applied as a broadcast, over-the-top, or directed spray on several ornamental species listed on the product label. **Comments.** Contact with rapidly growing tissues or buds may injure desirable plants. Wait until newly emerged vegetation has hardened off and apply overhead irrigation to the foliage to wash the herbicide onto soil. Directing sprays away from the foliage can also reduce injury potential. Delay applications to newly transplanted ornamentals until soil has settled around transplants. Prodiamine is most effective when product is activated before weeds emerge and within 14 days after application by irrigation or rainfall, or shallow mechanical incorporation. Areas treated with prodiamine should be rotated only to ornamental species listed on the product label for 1 year following application unless a successful bioassay has been conducted. Product label includes specific application instructions based on treatment site and bioassay instructions.

(continued)

Table 12. Herbicide descriptions *(continued)*

Common name	Trade name	Uses and comments
pronamide	Kerb	**Uses.** Restricted use pesticide. A fall application (when temperatures don't exceed 55°F, but prior to freeze-up) controls winter annual and perennial grasses and certain broadleaf weeds. For use on selected established woody ornamentals. **Comments.** For use only on established trees and woody ornamentals. Not for use on seedling trees or shrubs less than 1 year old or to fall-transplanted stock transplanted less than 1 year or to spring-transplanted stock transplanted less than 6 months. Herbicide activity is best in soils containing less than 4% organic matter. Rainfall or overhead irrigation is essential following application for effective weed control. See label for rotational restrictions.
simazine	Princep, Drexel Simazine	**Uses.** Preemergent residual control of several annual broadleaf and grass weeds. Primarily used on coniferous ornamentals and a few deciduous species – see product label for a specific list of tolerant ornamentals. **Comments.** Use lower rates on coarser textured soil and soil low in organic matter. Do not apply within 1 year after transplanting. Do not apply on seedbeds or cutting beds. Do not apply to Christmas trees or shelterbelt transplants less than 2 years of age. Wait until soil is firmly settled around roots prior to use.
s-metolachlor	Pennant Magnum	**Uses.** Preemergent control of many annual grasses, certain annual broadleaf weeds, and yellow nutsedge. Ornamental tolerance is very specific and listed on the product label. **Comments.** Apply before weeds emerge or after existing weeds have been removed. Do not apply to seedbeds, cutting beds, or unrooted cuttings before transplanting. Do not apply to plants until the soil has firmly settled around roots. When applied broadcast over-the-top of plant foliage, follow with sufficient overhead irrigation to wash product from the foliage to reduce the chance of injury.

References to pesticide products in this publication are for your convenience and are not an endorsement of one product or manufacturer over another. In some situations, the efficacy and phytotoxic effects of these products have not been tested and results may vary. You are responsible for using pesticides according to the manufacturer's current label directions. Follow directions exactly to protect the environment and people from pesticide exposure. Failure to do so violates the law.

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