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MANAGING TURFGRASS PESTS IN WISCONSIN

A guide for turfgrass professionals

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Turfgrasses cover an estimated 50 million acres in the United States according to the National Turf Foundation. Home lawns comprise about 66% of the United States' total turf acreage, with the remainder divided among golf courses, athletic fields, sod farms, cemeteries, and other related sites. In its many forms, the turfgrass management industry has an estimated economic impact of $40 billion per year in the United States. Ironically, the more intensively that turfgrass is managed, the greater the risk or susceptibility to attacks from diseases, insects, weeds, and animals. This publication describes the pest management options available to professional turfgrass managers to keep turf in top condition while limiting potential harm to the environment.

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Pesticide names

Pesticide names can be confusing because each chemical company or supplier may use different **commercial names** for the same compound. Commercial names, or trade names, are written in large print on the label or container. The common name of a pesticide does not differ among products and is the type used in this publication. Common names may or may not be listed on the label or container. Chemical names are required by law to be listed on the container label but are usually too long and complicated to be used by many people. The **chemical name** is derived from the structure of the active ingredient of a pesticide. Often the chemical name is shortened for everyday use. This is referred to as the **common name** of the pesticide. An example is MCPP, sometimes called mecoprop. This is an abbreviation of 2-(2-methyl-4-chlorophenoxy) propionic acid, which is the chemical name of the active ingredient. An example of a commercial name is MCPP-4 amine.

PEST MANAGEMENT & 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 preventive measures as well.

The primary goal of your pest management program is to maintain pest damage at an acceptable level. Years ago, coinciding 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 and effective tools for today's turfgrass manager but they are not a cure-all for all of our pest problems. Rather, they should be used in the context of an **integrated pest management (IPM)** program.

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. Today's IPM concept is based on a scientific and systematic approach. You must be familiar with the plant, the pest, and all available control tactics to develop and implement an IPM program.

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. 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 turfgrass). 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 the benefits of a pesticide to outweigh the risks only in certain cases due to various nontarget impacts, including injury to the applicator, it may classify the pesticide as restricted-use. Because restricted-use products can be used only by certified applicators, the FIFRA amendments also mandated each state develop a program for training and certifying pesticide applicators. The certification program ensures that users of restricted-use products (RUPs) are properly qualified to handle and apply these materials safely and efficiently.

For a full list of all pesticides registered in Wisconsin, including those registered as general use or as RUPs, visit the Kelly Solutions website (www.kellysolutions.com/wi/) operated by the Wisconsin Department of Agriculture, Trade, and Consumer protection (WDATCP).

Wisconsin's pesticide training and certification program

In Wisconsin, responsibility for pesticide training lies with the University of Wisconsin's Pesticide Applicator Training (PAT) program, and certification and licensing is the responsibility of WDATCP. The Wisconsin Pesticide Law requires that all commercial applicators for hire participate in the training and certification process for Category 3.0 (Turf and Ornamental) no matter which pesticides they intend to use. The Wisconsin Pesticide Law mandates that any person using RUPs also participate in the training and certification process. Other regulations involving when certification is legally required can be found at the PAT program website (https://fyi.uwex.edu/pat/).

The selection, use, and potential risks of pesticides vary depending on the method of application and what plants you seek to protect. Therefore, there is a separate training manual and certification exam for 21 different 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.

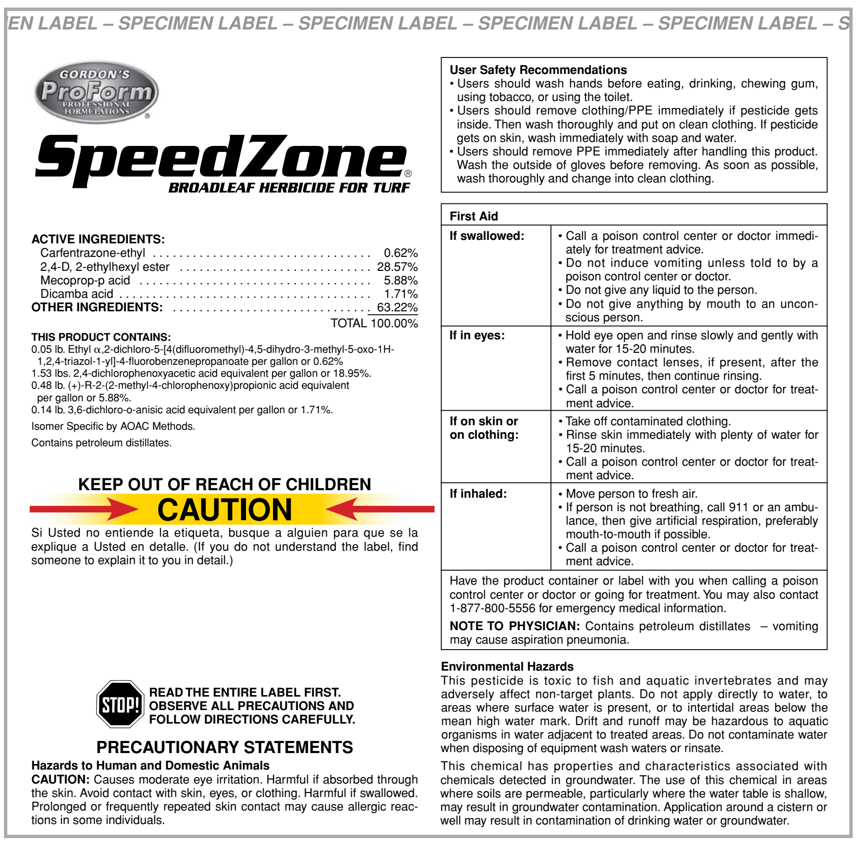
Pesticides and community right-to-know

To help communities evaluate their preparedness for responding to chemical spills, the U.S. Congress passed the Emergency Planning and Community Right-to-Know Act (EPCRA). This law is part of the much larger SARA legislation 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 used in turf pest management. For more information on the Wisconsin SARA law, visit the Wisconsin ECPRA website (https://dma.wi.gov/DMA/wem/preparedness/epcra).

Wisconsin pesticide laws and regulations

Operating under the provisions of the Wisconsin Pesticide Law and Administrative Rule, Chapter ATCP 29, 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" and the control of birds and mammals. Wisconsin Emergency Management (WEM) has responsibility for helping communities evaluate their preparedness for responding to accidental releases of hazardous compounds, including some pesticides, under Title III of the Superfund Amendments and Reauthorization Act (SARA). Finally, it is your obligation to become familiar with all pertinent laws and regulations and to adhere to them explicitly, many of which are covered in the Category 3.0 Pesticide Applicator Training and certification materials.



EN LABEL – SPECIMEN LABEL – SPECIMEN LABEL – SPECIMEN LABEL – SPECIMEN LABEL – S

GORDON'S ProForm PROFESSIONAL FORMULATIONS®

SpeedZone®
BROADLEAF HERBICIDE FOR TURF

ACTIVE INGREDIENTS:

Carfentrazone-ethyl	0.62%
2,4-D, 2-ethylhexyl ester	28.57%
Mecoprop-p acid	5.88%
Dicamba acid	1.71%
OTHER INGREDIENTS:	63.22%
TOTAL	100.00%

THIS PRODUCT CONTAINS:
0.05 lb. Ethyl α,2-dichloro-5-[4(difluoromethyl)-4,5-dihydro-3-methyl-5-oxo-1H-1,2,4-triazol-1-yl]-4-fluorobenzenepropanoate per gallon or 0.62%
1.53 lbs. 2,4-dichlorophenoxyacetic acid equivalent per gallon or 18.95%.
0.48 lb. (+)-R-2-(2-methyl-4-chlorophenoxy)propionic acid equivalent per gallon or 5.88%.
0.14 lb. 3,6-dichloro-o-anisic acid equivalent per gallon or 1.71%.

Isomer Specific by AOAC Methods.

Contains petroleum distillates.

KEEP OUT OF REACH OF CHILDREN
CAUTION

Si Usted no entiende la etiqueta, busque a alguien para que se la explique a Usted en detalle. (If you do not understand the label, find someone to explain it to you in detail.)

STOP! **READ THE ENTIRE LABEL FIRST. OBSERVE ALL PRECAUTIONS AND FOLLOW DIRECTIONS CAREFULLY.**

PRECAUTIONARY STATEMENTS

Hazards to Human and Domestic Animals
CAUTION: Causes moderate eye irritation. Harmful if absorbed through the skin. Avoid contact with skin, eyes, or clothing. Harmful if swallowed. Prolonged or frequently repeated skin contact may cause allergic reactions in some individuals.

User Safety Recommendations
- Users should wash hands before eating, drinking, chewing gum, using tobacco, or using the toilet.
- Users should remove clothing/PPE immediately if pesticide gets inside. Then wash thoroughly and put on clean clothing. If pesticide gets on skin, wash immediately with soap and water.
- Users should remove PPE immediately after handling this product. Wash the outside of gloves before removing. As soon as possible, wash thoroughly and change into clean clothing.

First Aid	
If swallowed:	• Call a poison control center or doctor immediately for treatment advice. • Do not induce vomiting unless told to by a poison control center or doctor. • Do not give any liquid to the person. • Do not give anything by mouth to an unconscious person.
If in eyes:	• Hold eye open and rinse slowly and gently with water for 15-20 minutes. • Remove contact lenses, if present, after the first 5 minutes, then continue rinsing. • Call a poison control center or doctor for treatment advice.
If on skin or on clothing:	• Take off contaminated clothing. • Rinse skin immediately with plenty of water for 15-20 minutes. • Call a poison control center or doctor for treatment advice.
If inhaled:	• Move person to fresh air. • If person is not breathing, call 911 or an ambulance, then give artificial respiration, preferably mouth-to-mouth if possible. • Call a poison control center or doctor for treatment advice.

Have the product container or label with you when calling a poison control center or doctor or going for treatment. You may also contact 1-877-800-5556 for emergency medical information.

NOTE TO PHYSICIAN: Contains petroleum distillates – vomiting may cause aspiration pneumonia.

Environmental Hazards
This pesticide is toxic to fish and aquatic invertebrates and may adversely affect non-target plants. Do not apply directly to water, to areas where surface water is present, or to intertidal areas below the mean high water mark. Drift and runoff may be hazardous to aquatic organisms in water adjacent to treated areas. Do not contaminate water when disposing of equipment wash waters or rinsate.

This chemical has properties and characteristics associated with chemicals detected in groundwater. The use of this chemical in areas where soils are permeable, particularly where the water table is shallow, may result in groundwater contamination. Application around a cistern or well may result in contamination of drinking water or groundwater.

FIGURE 1. Herbicide label with signal word.
Label courtesy of CDMS.net.

TABLE 1. Toxicity categories of pesticides.

Measure of toxicity	Toxicity category: I Highly toxic	II Moderately toxic	III Slightly toxic	IV Relatively nontoxic
Oral LD_{50} (mg/kg)	0–50	50–500	500–5,000	>5,000
Dermal LD_{50} (mg/kg)	0–200	200–2,000	2,000–20,000	>20,000
Inhalation LC_{50} (mg/l)				
gas/vapor (ppm)	0–200	200–2,000	2,000–20,000	>20,000
dust/mist (µg/l)	0–2,000	2,000–20,000	20,000–200,000	>200,000
Eye effects	corrosive	irritation for 7 days	irritation for 7 days	none
Skin effects	corrosive	severe irritation	moderate irritation	mild irritation
Signal word/symbol	DANGER or DANGER/POISON[a] with skull & crossbones	WARNING	CAUTION	CAUTION

Abbreviations: mg/kg = milligrams per kilogram; ppm = parts per million; < = less than; > = 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.

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 (ocular). Absorption through the skin is the most common route of poisoning of pesticide users.

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 concentrated 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 not implemented. A pesticide may be toxic from 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 milligrams per liter (mg/l). Note that both mg/kg and mg/l can also be expressed as parts per million (ppm).

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 (figure 1) and symbols that are established by law and reflect general categories of toxicity (table 1). 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.

Human pesticide poisoning

Pesticide poisoning must be recognized early for effective treatment

Early symptoms of pesticide poisoning 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 may feel constricted and breathing may become 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 safety data sheet (SDS) contain first aid information and additional information for medical personnel. Immediately take the victim to professional medical help and bring a copy of the SDS, 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

You may call the Poison Control Center (1-800-222-1222) 24 hours a day for information regarding proper treatment of pesticide poisoning. While hospitals and medical facilities may have some information, the Poison Control Center has the most complete and current data, 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 the 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, the general public, and the environment.

- The pesticide label will provide a detailed description of the personal protective equipment (PPE) legally required for you to wear when applying the product. Though it varies by product and task, the minimum required PPE is often a long-sleeved shirt, long pants, shoes, and socks.
- Never apply pesticides when there is the likelihood of significant drift (high wind, very warm temperatures, temperature inversion, etc.).
- Never leave a spray tank containing pesticide unattended.
- Maintain an air-gap between the water source (i.e., hose) and the spray tank when filling the tank to prevent 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. If the contaminated clothing is saturated, discard clothing and do not try to wash.
- Wash contaminated clothes separately from other household laundry.
- Keep pesticides in original containers.
- Store and lock pesticides out of the reach of children.

Pesticide accidents

Pesticide spills

Regardless of the magnitude of a spill, the objectives of a proper response are the same. Protect yourself with PPE before responding, then you must **control** the spill, you must **contain** the spill, and you must **clean** the spill 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. 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, it is less than the reportable quantity.

Reportable spills involving SARA substances (see **Pesticides and community right-to-know**, page 2) must be reported to WEM, your Local Emergency Planning Committee (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 the WDNR's 24-hour spill hotline (1-800-943-0003) whenever a spill of any compound occurs. Calling this hotline will not remove your responsibility of notifying your LEPC if the spilled substance is a SARA compound. Spills of some compounds may require that you notify federal authorities by calling the National Response Center (1-800-424-8802). Your call to WDNR's spill hotline will 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).

Wildlife poisoning or water contamination

Contact the WDNR district office if wildlife poisoning or water contamination is suspected. District offices are located in Spooner, Rhinelander, Eau Claire, Green Bay, Milwaukee, and Fitchburg and their phone numbers can be found at the WDNR website (http://dnr.wi.gov/contact/officelocations.html).

Pesticide drift

Wisconsin prohibits significant drift that is readily visible or that causes harm (or could conceivably cause harm) to a nontarget area. It is impossible to totally eliminate pesticide drift, but there are several techniques that can be used to minimize drift. Drift occurs because of unforeseen wind variations and other factors, many of which are beyond the applicator's control. However, damage due to significant drift is always the responsibility of the applicator. 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, beekeepers that request notification in writing are entitled to notification by the landowner at least 24 hours prior to the application when it occurs within a 1.5-mile radius of their honeybee colonies. If you are applying a pesticide labeled as highly toxic to bees, you should notify the landowner so they can inform any beekeepers that have requested notification. In addition, residents on the Landscape Pesticide Registry notification list (http://datcpservices.wisconsin.gov/landreg/) must be given at least 12 hours' notice prior to any "for hire" applications that will be made on the same or an adjoining block. If the notification is to be provided in writing, it must be postmarked 48 hours before the scheduled application.

Use the following recommendations to minimize pesticide drift:

- Follow all label precautions for specific drift-reduction measures. Many labels now have maximum wind speeds.
- Spray when wind speed is low (less than 10 mph) but avoid spraying when there is a dead calm.
- Keep pressure at the setting recommended by the nozzle manufacturer.
- Consider using nozzles specifically designed to reduce drift.
- Leave an untreated border strip next to adjacent property or near sensitive plants such as tomatoes.
- Use low-volatility herbicides when possible to reduce chemical drift due to volatilization.

Pesticides and groundwater

Trace amounts of pesticides appear 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.

To protect our state's water resources, Wisconsin's Groundwater Law (ATCP 31) 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.

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 pounds 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. Mixing or loading pesticides is **never** permitted within 8 feet of a well or surface water, with the exception of labeled aquatic applications.

Agricultural Chemical Cleanup Program (ACCP)

Cleanup of contaminated soil or of contaminated groundwater itself is costly. The ACCP 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 608-224-4500.

Calibrating pesticide equipment

Accurate and uniform pesticide application is a fundamental aspect of satisfactory pest control. Too often an applicator 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, and reduced turf quality.

Effective pesticide applications begin with accurate sprayer or granular applicator calibration. One method of calibration is described in the *Training Manual for the Commercial Pesticide Applicator: Turf and Landscape* available at https://fyi.uwex.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, or when any product is used following the application of a nonselective herbicide (i.e., glyphosate). Pesticide labels provide detailed instructions on cleaning spray tanks, and these instructions often vary among different products. You are required to follow the label instructions when cleaning a pesticide sprayer.

Preparing pesticide sprayers for storage

Follow these guidelines before storing pesticide sprayers at the end of the season:

1. Clean the sprayer per label instructions or as specified below.
2. Fill the sprayer with sufficient water to operate and add 1 to 5 gallons of lightweight emulsifiable oil, depending on the size of the tank. Circulate the oil-and-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-inhibiting 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 pesticide containers in Wisconsin.

Some pesticides or byproducts of pesticides can be designated as "hazardous waste" by the EPA. For more information on how the EPA defines hazardous waste, visit the EPA's hazardous waste website (https://www.epa.gov/hw/defining-hazardous-waste-listed-characteristic-and-mixed-radiological-wastes). 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 Waste and Emergency Management personnel. 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 the WDATCP website (https://datcp.wi.gov/Pages/Programs_Services/CleanSweep.aspx) 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 Agri-Business Association (WABA) through the Ag Container Recycling Council (ACRC) funds and administers this program 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 WABA website (http://www.wiagribusiness.org/recycling.html) to find out when a collection site will be in your area. 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 first 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.

WEED MANAGEMENT

A weed is simply a "plant out of place," and there are numerous cases of plants that are desirable in one location and weeds in another. For example, creeping bentgrass is a desirable plant on most areas of a golf course because of its ability to withstand low mowing heights. But in home lawns, creeping bentgrass is a weed due to its nonuniform appearance and susceptibility to disease relative to other common lawn turfs. Kentucky bluegrass is a desirable plant in most home lawns, but in ornamental beds or in sidewalk cracks, Kentucky bluegrass is usually considered a weed. Knowing when a plant is a weed versus when it is desirable is the first step in proper weed management. Additional information on weed management in lawns can be found in UW-Extension publication A1990, *Lawn Weed Prevention and Control*, available at the UW-Extension Learning Store.

Identification

Control methods for weeds are species specific. Therefore it is critical to identify the weed species of concern prior to determining an effective control method. While knowledge of weed's life cycle (annual, biennial, or perennial) will help in the decision process, species identification will allow turfgrass managers to tailor management methods, increasing effectiveness.

For assistance in identifying common turfgrass weeds in Wisconsin, visit the University of Wisconsin Weed Identification and Management website (weedid.wisc.edu) or submit a sample to the University of Wisconsin Turfgrass Diagnostic Lab (tdl.wisc.edu).

Cultural management strategies

The most effective weed management strategy is the presence of healthy and dense turfgrass plants that crowd or shade out competitors. Weeds often appear in bare or thin areas between turfgrass plants, which can be the result of improper management, poor environmental conditions, or both. Improper management can include a mowing height that is too low, lack of adequate fertilization, too much or too little water, excessive traffic, or selecting the wrong turfgrass species for the site conditions. Herbicides are effective at removing most weeds, but those weeds will return if turf management activities are not corrected. If management activities can be altered to improve turf health, the frequency of herbicide applications can often be significantly reduced if not eliminated. More information on proper cultural practices for Wisconsin turfgrass managers can be found in the UW-Extension publications listed in table 2.

TABLE 2. UW-Extension publications related to proper lawn management are available at the UW-Extension Learning Store (learningstore.uwex.edu) under the *Lawn and Garden* category.

Publication number	Title
A1990	*Lawn Weed Prevention and Control*
A3435	*Lawn Maintenance*
A2303	*Lawn Fertilization*
A3950	*Watering Your Lawn*
A3700	*Growing Grass in Shade*
A3710	*Lawn Aeration and Topdressing*
A3958	*Organic and Reduced-Risk Lawn Care*

Chemical management strategies

Sometimes weeds remain persistent even after implementing sound cultural practices, and in these instances herbicides can be an effective and economical way to control turfgrass weeds. However, knowledge about both the weed and the herbicide to use is required to effectively manage the weed while avoiding harm to the desired turfgrass.

For the most up-to-date information on which herbicides are most effective against each weed in turfgrass, visit the Turf Pest Management website at https://turfpests.wisc.edu (figure 2).

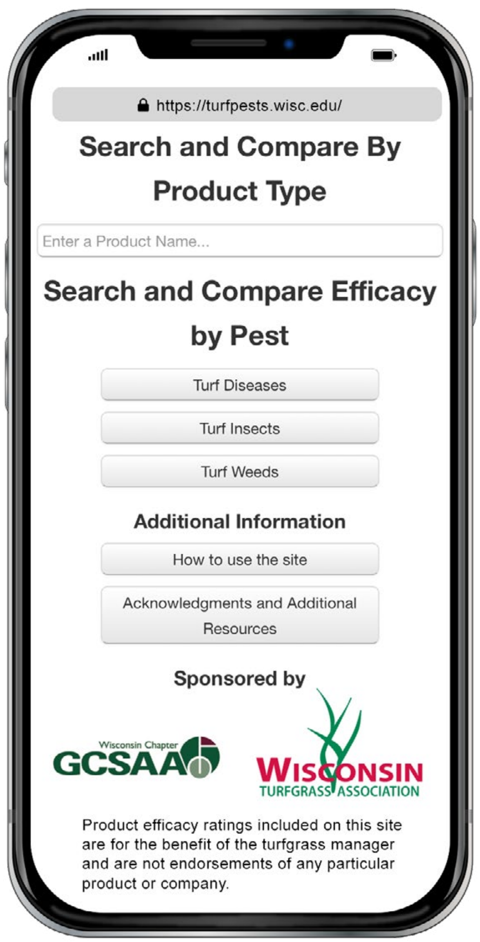


FIGURE 2. The University of Wisconsin Turf Pest Management mobile website (https://turfpests.wisc.edu).

Contact vs. systemic herbicides

Contact and systemic herbicides each have unique advantages and disadvantages (table 2). Contact herbicides (e.g., diquat) only kill the portion of the plant they come into contact with, which makes herbicide coverage critical for effective weed management. Contact herbicides work quickly, often causing dieback symptoms within 24 hours of application, and are most effective on annual weeds. However, contact herbicides are largely ineffective in managing perennial weeds. Systemic herbicides (e.g., 2,4-D) are absorbed and moved throughout the plant. They work best when applied in the fall. Systemic herbicides can take several days or even multiple weeks to display symptoms depending on the temperatures present at the time of application. In certain situations, a systemic herbicide will be mixed with a contact herbicide to provide a quicker knockdown of the weed and long-lasting control of its underground storage organs.

TABLE 2. Herbicides can be classified as selective or nonselective.

Selective	Nonselective
Selective herbicides control one type of plant but not another. Most often, selective herbicides are used to control broadleaf weeds (e.g., dandelion) while not harming the turf. Most herbicides are selective, including 2,4-D and dicamba. Note that if applied under stressful conditions, at the wrong rate, or to the wrong turfgrass species, selective herbicides can damage or kill the desired turfgrass. Read the herbicide label carefully to determine which turfgrass species the herbicide can safely be applied to and at what rate.	**Nonselective** herbicides control any plant they come into contact with, including turfgrass. Common nonselective herbicides are glyphosate (e.g., Roundup®), glufosinate, and diquat. Read the label carefully to determine if an herbicide is nonselective.

Annual weeds

Annual weeds are common in turf when bare soil exists between plants (table 3). Both broadleaf (e.g., prostrate knotweed) and grass (e.g., crabgrass) annual weeds are common in Wisconsin turf and complete their entire life cycle within one year. Winter annual weeds germinate from seed in the fall, go dormant during the winter months, resume growth in the spring, then produce seed in the late spring or early summer and die. Examples of winter annual weeds include common chickweed, henbit, and downy brome. Summer annual weeds are more common and germinate in spring, grow rapidly through the summer, and produce seed during the summer before dying in the fall. Examples of summer annual weeds include crabgrass, prostrate knotweed, and purslane.

Herbicide applications can be made to these weeds before they germinate (preemergence) or after they germinate (postemergence). The most consistent control of annual weeds is typically obtained with preemergent herbicides. These herbicides are retained near the surface of the soil and are absorbed by weed seeds as they germinate. Affected seeds die shortly after germination, and never emerge above the soil surface. Optimal preemergence timing will vary with each weed, but crabgrass preemergence applications are most effective when the product is applied when soil temperatures at a 2-inch depth reach 50°F for five consecutive days. This normally occurs in mid-April in southern Wisconsin and late April or early May in northern Wisconsin. A range of herbicides are available for this use and can provide 1 to 3 months of effective annual weed control. Postemergent herbicide applications can also be used to control weeds that have emerged and should be applied prior to seed production to prevent future spread of the weed. For postemergence control of annual weeds, applications are most effective when weeds are small (less than 3 inches tall or in diameter) and actively growing.

Perennial weeds

Perennial weeds are very common in Wisconsin lawns and can be either broadleaf (dandelion, white clover, ground ivy) or grass (quackgrass) species (table 3). Perennial weeds are usually controlled using postemergent herbicides since preemergent herbicides are most effective at suppressing annual weed seed germination. Optimal suppression of perennial weeds will depend on selecting an effective herbicide and applying it at the proper rate and time. Optimal timing of a postemergent herbicide application is specific to the weed species and product selected, so consult the herbicide label prior to treatment. Fall herbicide applications usually provide the most effective long-term control of perennial weeds because the herbicide is more effectively translocated downward to the plant's long-term storage organs. Spring herbicide applications usually provide the least effective long-term control of perennial weeds. Summer applications are usually not recommended for perennial weed control except for the control of yellow nutsedge.

TABLE 3. Common annual and perennial weeds in Wisconsin turfgrass.

Annual	Perennial
Crabgrass (grass)	Quackgrass (grass)
Prostrate knotweed (broadleaf)	Dandelion (broadleaf)
Common chickweed (broadleaf)	White clover (broadleaf)
Henbit (broadleaf)	Creeping Charlie/ground ivy (broadleaf)
Annual bluegrass (grass)	Violet (broadleaf)
Purslane (broadleaf)	Plantains (broadleaf)
Prostrate spurge (broadleaf)	Yellow nutsedge (sedge)
	Nimblewill (grass)
	Canada thistle (broadleaf)

Organic and reduced-risk herbicides

Demand for organic lawn management programs are increasing throughout North America in response to municipal bans on pesticide usage on turfgrass. Unfortunately, there are very few organically certified herbicides in turf. Acetic acid (i.e., vinegar) in a solution of 7% or less is allowed in certified organic production and can serve as a nonselective herbicide. Corn-gluten meal produced from non-genetically modified corn is also allowed in certified organic production and can be used as a preemergent herbicide as well as a source of nitrogen. For more information on organic and reduced-risk turf management, consult UW-Extension publication A3958, *Organic and Reduced-risk Lawn Care*.

Herbicide resistance

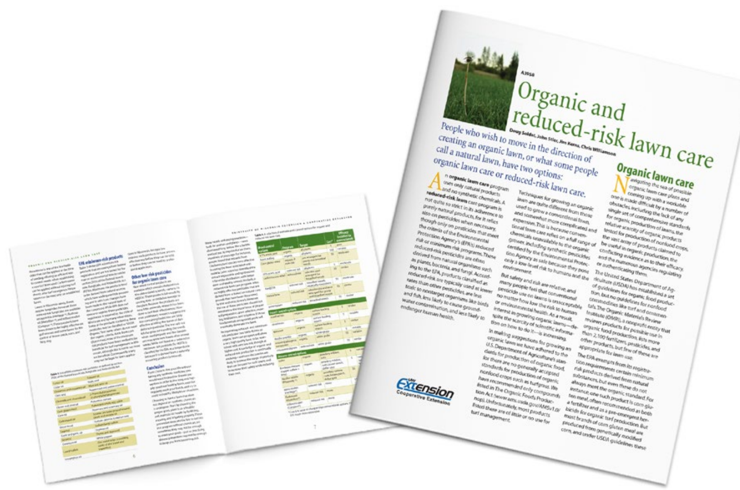
Repeated use of herbicides with the same chemical mode of action (i.e., manner in which the herbicide kills the weed) can contribute to buildups of herbicide-resistant weeds. Herbicide resistance in most turfgrass weeds generally develops slower than resistance in insect or disease pests, but documented cases of herbicide resistance in cool-season turfgrass has been reported in smooth crabgrass (resistant to fenoxaprop and quinclorac) and buckhorn plantain (resistant to 2,4-D). In general the most common type of herbicide resistance is to glyphosate (i.e., Roundup®), and numerous glyphosate-resistant weeds have been documented in agriculture and in turf in the transition zone where glyphosate is more commonly applied over a broad area to dormant warm-season turf.

To minimize the risk of developing herbicide resistant weeds:

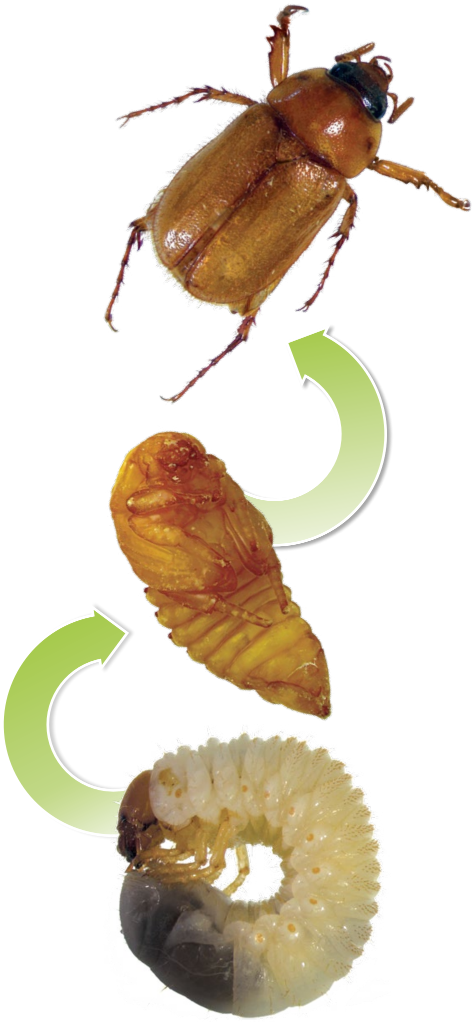
- Plant grass species known to create dense turf to reduce weed competition.
- Fertilize turf to promote density and decrease weed competition.
- Use preemergence herbicides to prevent the establishment of troublesome weeds.
- Alternate or tank-mix herbicides from different chemical classes.
- Use Herbicide Resistance Action Committee (HRAC) codes to help determine which products are in what chemical class. HRAC codes for all herbicide active ingredients are available at the HRAC website (http://hracglobal.com/tools/classification-lookup).
- Never apply an herbicide at a rate below the lowest recommended label rate.
- Use herbicides as part of an IPM plan to limit the number of herbicide applications made in a given year.

Other herbicide considerations

Effectiveness and safety to the turf vary widely depending on the product, application rate, timing, turf species, and many other factors. For instance, few herbicides are labeled for golf course greens because of the high potential for injury on the closely mowed bentgrass turf. Be aware of the soil type, as in some cases this dictates the rate, or even which herbicides can legally be applied. Also consider the surrounding vegetation when applying herbicides, as drift can impact growth of other species. Ornamental plants or flowerbeds are often present within or near the turf and are usually highly susceptible to herbicide injury. Injury can occur from foliar uptake (postemergent applications) or root uptake (pre or postemergent applications). In rare cases, some herbicides can even volatilize, move as a vapor, and injure nontarget plants. Updated herbicide formulations have limited this volatilization and drift risk to some degree, but volatilization can still occur, particularly if applications occur on hot days (greater than 85°F) or near impervious surfaces. The herbicide label provides guidance and precautions and should always be consulted prior to application to determine optimal application conditions and drift-mitigating techniques.



For more information on organic and reduced-risk turf management, consult UW-Extension publication A3958, *Organic and Reduced-risk Lawn Care*.



Above: Northern masked chafer (*Cyclocephala borealis* Arrow) larva (grub), pupa, and adult beetle.

INSECT PEST MANAGEMENT

The keys to successful pest management are accurate identification and an understanding of the pest's life cycle. Identification will tell you whether the insect or mite is beneficial or destructive. It will also help you determine what plants it feeds on and when during its life cycle it is most susceptible to pest management strategies.

For help with identification, contact your county Extension office, visit the UW-Extension Learning Store (learningstore.uwex.edu), or contact the UW–Madison Insect Diagnostic Lab (labs.russell.wisc.edu/insectlab)

Monitoring

Understanding the biology of turfgrass insects and mites will improve your ability to predict when damaging stages or pest numbers are likely to be present. Periodically inspect the turf for potential pests and damage. You'll need to closely examine turfgrass leaves and thatch, and periodically lift or remove the turf to inspect for the signs of insects, especially white grubs (figure 3). To help with monitoring you may want to consider using methods such as soap drenches to bring pests to the surface. The presence of animals or birds may indicate an infestation of turfgrass insect pests. Specific information on the life cycle of turfgrass insect and mite pests and specific monitoring methods is available from your county Extension office or online at the UW-Extension Learning Store.

Selecting a control tactic

There are three general strategies for managing pests: **cultural**, **biological**, and **chemical**. These strategies may be used singly or together as part of an IPM program. The objective of IPM is to manage pests effectively, economically, and with minimal risks to people and the environment. IPM relies on a combination of preventive and corrective measures to maintain pest densities below a specific and measurable population level (known as the action threshold) where damage is unacceptable. When the pest density reaches this specified level, control measures are justified. The levels must be set by individual turfgrass managers and will vary considerably depending upon factors such as turf location, aesthetics and replacement value, safety, budget and pest species. Each species of white grub, for example, has its own suggested threshold; minimum thresholds may be as low as 6–10 per ft^2 although irrigated turfs may be able to sustain as many as 20 grubs/ft^2 before treatment is required.

Under IPM, the presence of insects or mites is not sufficient reason to implement a control tactic. A healthy turf environment will often contain numerous beneficial invertebrates—some may prey upon or parasitize other insect pests, while others help in the cycling of decaying organic matter.

FIGURE 3. White grub damage to turf accentuated by a vertebrate animal scavenging for grubs.

Cultural control

Cultural control involves reducing pests or their damage through normal or modified management practices. These practices can significantly impact the absence or presence of pests. Fertility, irrigation, mowing practices, thatch management, and insect resistant turf species are all important cultural control techniques that can reduce insect and mite pests in turf. A healthy or vigorous turf can often withstand higher insect populations that would normally destroy a weak, stressed turf, and mask damage that does occur.

A balanced **fertility program** provides controlled shoot growth, a deep and extensive root system, and good recuperative properties. Thus, turf recovery from insect damage occurs quicker.

Irrigation can have either positive or negative effects on injury depending on the insect species. Many root-feeding insects, particularly white grubs, require moist soil for survival of eggs and larvae. Dry soil conditions can cause adult beetles to seek out alternative (i.e., moist) turf areas to lay their eggs. Conversely, chinch bugs require hot, dry conditions for optimal survival and reproduction. Thus, watering during hot, dry periods can reduce chinch bug populations as well as promote conducive conditions for a fungal pathogen that negatively impacts chinch bugs.

The selection of the mowing height can influence turf vigor, which can affect the susceptibility to insects. Properly cut turf is more tolerant of insect damage.

Preventing thatch development or removing existing thatch minimizes potential shelter for certain insect pests as well as improving the effectiveness of pesticides when needed.

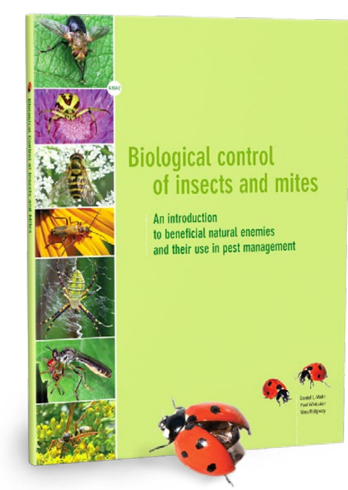
Insect-resistant turfgrasses can also be a valuable tool. Well-adapted turfgrasses are able to withstand stress, and tolerate and recover from damage caused by insects. Different turfgrass species vary in susceptibility to specific insect pests. There are also differences within a turfgrass species. Varieties of a turfgrass species can have variable degrees of genetic resistance to particular insect pests. Mutualistic or "friendly" fungal pathogens called endophytes are fungi located within turfgrass plants. Endophytes protect the plant by producing specific chemicals that are detrimental to insect pests. However, not all turfgrass species are infected with or are capable of hosting endophytes. Perennial ryegrass, tall fescue, and some fine fescues (hard, chewings, creeping red) can have endophyte-infected varieties. Furthermore, not all insects are affected by the endophyte-infected turfgrasses.

There is no "silver-bullet" or one specific agent, method, or tactic for controlling turfgrass insect pests. For these reasons, a comprehensive IPM program should be developed and adopted by all turfgrass managers to economically, effectively, and safely manage turfgrass insect pests.

Biological control

Biological control is the use of predators, parasitoids, and disease-causing microbes or pathogens to suppress pest populations. The intention is to establish one of the aforementioned natural agents that suppress a pest in its native habitat. The best form of biological control for turfgrass managers is the conservation of natural enemies. A healthy or vigorous turf supports many naturally occurring predators, parasites, and pathogens that help keep pest populations below aesthetic injury levels or action thresholds.

Ground and rove beetles readily attack several species of turfgrass caterpillars as well as their eggs and the eggs of white grubs. In addition, a number of flies and wasps parasitize turfgrass insects. Not only do certain insects control other insects, but there are also several diseases that attack insects as well. Some of these disease-causing organisms occur naturally and can be found in the soil/turf canopy. A few of these biological control products are commercially available. These products include bacterial milky disease (*Bacillus popilliae*), several strains or varieties of the bacterium Bt (*Bacillus thuringiensis*), and a fungal pathogen (*Beauvaria bassiana*), and several species of entomopathogenic nematodes (*Heterorhabditis bacteriophora*, *Steinernema carpocapsae*, and others). Although these products are registered and marketed as viable control agents for turfgrass insect pests, research data suggests that the effectiveness of these products can be highly variable and often provide limited control.



For an introduction to beneficial natural enemies to insect pests, consult UW-Extension publication A3842, *Biological Control of Insects and Mites*.

Chemical control

For the most up-to-date information on which insecticides are most effective against each insect pest, visit the Turf Pest Management website (https://turfpests.wisc.edu).

Preventive vs. curative applications

Timing of insecticide treatments is an important decision. Should the control product be applied as a preventive or a curative treatment? Preventive treatments are made before there are any signs of pests or damage. The intention is to prevent an outbreak or establishment of a pest. Curative treatments are made after a pest is observed, and ideally before any significant damage has occurred. With careful monitoring, most insects can be successfully managed after they are discovered and before they cause measurable or damage above the action threshold.

One of the drawbacks to preventive treatments is that because chemicals are applied before pests appear, treatments are often made when no damage would have occurred. Thus, unnecessary applications may be made.

When making a decision to apply an insecticide as a preventive control measure, consider that many beneficial predators and parasitoids may be destroyed. The best way to conserve natural enemies is through judicious insecticide selection and use: limit use of broad-spectrum insecticides and treat only when and where pest populations are above the aesthetic injury level or action threshold.

Insecticide resistance

Repeated use of insecticides with the same chemical mode of action (i.e., the manner in which the insecticide kills the insect) can contribute to buildups of insecticide-resistant insect populations.

To minimize the risk of developing insecticide-resistant pests:

- Alternate or tank-mix insecticides from different chemical classes.
- Use Insecticide Resistance Action Committee (IRAC) codes present on the front of most insecticide labels to help determine which products are in what chemical class. The IRAC code can be found in the upper right corner of most insecticide labels (figure 4).
- If an IRAC code is not present on the label, visit the IRAC website (www.irac-online.org) to determine which chemical class your insecticide is in.
- Never apply an insecticide at a rate below the lowest recommended label rate.
- Use insecticides as part of an IPM plan to limit the number of insecticide applications required in a given year.

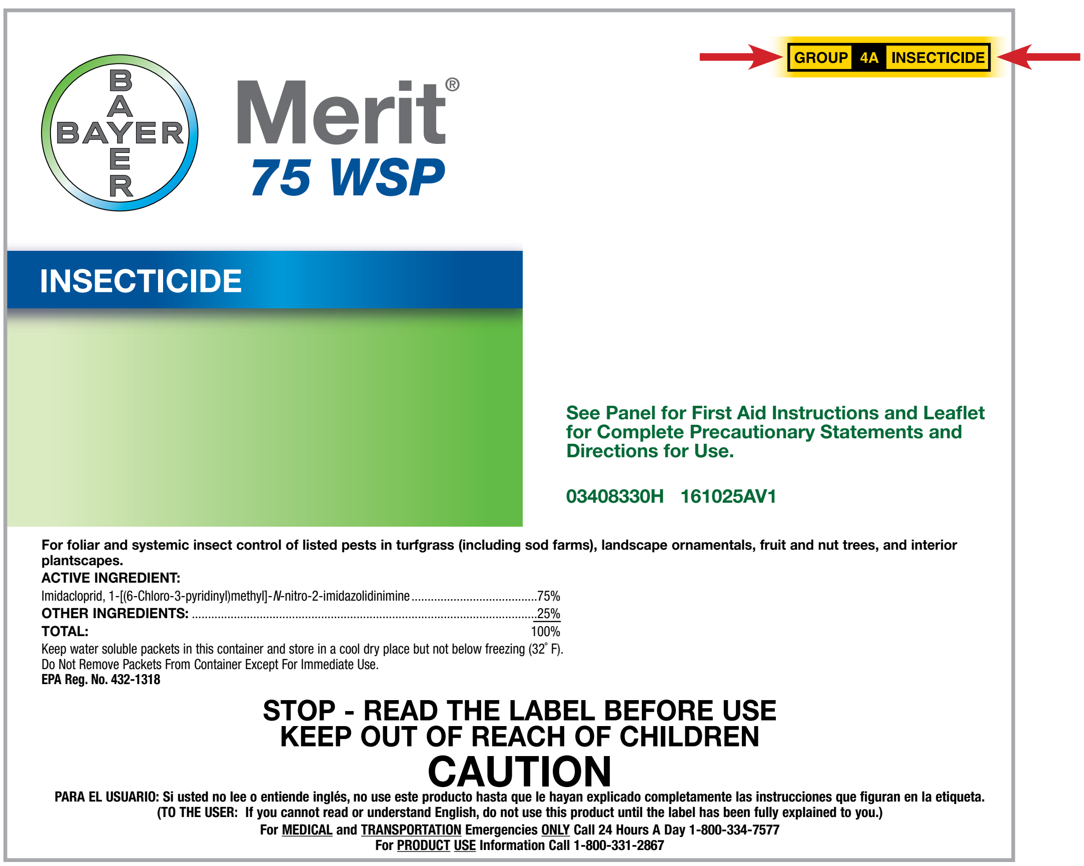


FIGURE 4. Insecticide label with IRAC code.
Label courtesy of CDMS.net.

Protecting pollinators in turfgrass

For more detailed information on protecting pollinators in turfgrass, consult UW-Extension publication A4128, *Conservation of Native and Domestic Pollinators in Managed Turfgrass Landscapes*.

Insect pollinators are an important component of native ecosystems as well as many agricultural and horticultural crops. Pollinator populations have declined in many environments due to a number of factors, including habitat loss, diseases and parasites, and certain insecticide applications. To minimize potential harm to pollinators from insecticide applications made to turfgrass sites, managers should follow best management practices:

- **Mow the application area.** Avoid applying liquid insecticides to the blooming portion of flowering weeds (dandelion, white clover, etc.). Any blooming flowers present in the turf should be mowed off or removed prior to applying the insecticides. Controlling flowering weeds prior to bloom with an herbicide application is another viable strategy.
- **Consider application timing.** Wait to treat until after the peak bloom of weeds to avoid contamination. Wait to treat until evening when pollinators have usually finished foraging.
- **Consider the insecticide formulation.** Granular insecticide products ensure insecticide residues go into the soil rather than into blooms of flowering weeds.
- **Consider the insecticide class.** Older classes of insecticides have documented effects against pollinators. Chlorantraniliprole, a newer insecticide, has been demonstrated as less dangerous for pollinating insects.
- **Follow label directions for irrigation.** Managers should use post-treatment irrigation to flush insecticide residues from the turf canopy to the root zone where pollinators do not forage.

For more information on protecting pollinators in turfgrass, consult UW-Extension publication A4128, *Conservation of Native and Domestic Pollinators in Managed Turfgrass Landscapes*.

Managers can also play an active role in pollinator conservation by increasing pollinator habitat in areas surrounding turfgrass. Habitat can be increased by planting a variety of flowering plants that have different colors and shapes, and flower at different times of the season to ensure a variety of food sources for different pollinators. This can include plants like New England aster, bergamot, black-eyed Susan, purple coneflower, and prairie coneflower. More information on increasing pollinator habitat can be found by contacting the Pollinator Partnership (www.pollinator.org/guides).

The above practices are adapted from the *Best Management Practices for Turf Care and Pollinator Conservation* fact sheet produced by authors Jonathan Larson, David Held, and Chris Williamson (https://turfinsects.triforce.cals.wisc.edu/wp-content/uploads/sites/110/2017/04/Pollinator-BMP-Booklet-Center-IPM-2017-04-10-2017.pdf).

DISEASE MANAGEMENT

Turfgrass plants are considered diseased when a fungal, bacterial, or viral organism causes abnormal alterations in either the appearance or growth rate of the plant. These abnormal alterations are referred to as symptoms and can include lesions present on individual leaf blades, blighting of entire plants, or discoloration or even death of turfgrass plants in patches up to several feet in diameter.

For diseases to occur there must be a susceptible host plant, a pathogenic organism, and a conducive environment all present at the same time; a concept known as the disease triangle (figure 5). Creeping bentgrass is often a highly susceptible host of many fungal pathogens, which is one reason why golf courses often see higher incidences of disease versus lawns and athletic fields, which typically contain more disease-resistant grass species such as Kentucky bluegrass, perennial ryegrass, and fine fescue.

Nearly all turfgrass diseases in Wisconsin are caused by pathogenic fungi. Fungi can disrupt the plant's physiological processes by penetrating the turfgrass leaves, stems, and roots. In addition, fungi can also incite disease by altering the surrounding environment (e.g., fairy ring) or growing exclusively on the outside of the plant (e.g., slime mold). Turfgrass diseases caused by bacteria, viruses, and nematodes rarely cause significant damage on turfgrass in Wisconsin.

For more information about the most common turfgrass diseases observed in Wisconsin and throughout the Great Lakes region, consult UW-Extension publication A3187, *Turf Diseases of the Great Lakes Region*.

Diagnosing turfgrass diseases

Accurate disease diagnosis is important for implementing proper control strategies, which can include alteration of cultural practices, application of a fungicide, or both. Accurately diagnosing diseases can be very difficult, since many symptoms appear similar to each other and can also appear similar to damage caused by insects or abiotic agents such as drought, soil compaction, or chemical damage (view the sidebar on the following page for ways to differentiate diseases from abiotic damage).

The first step in proper diagnosis is to observe the symptom appearance, which can appear as small spots, larger patches, rings, or even irregular masses of blighted turf. In some cases, mycelium or other structures produced by the fungus will be present and are an excellent indicator of which disease is present. The second step is to identify the grass species affected. Grass species are resistant to some diseases and susceptible to others, so proper grass identification can typically narrow down the possible diseases. The third step is to take into account recent environmental conditions. Each disease has an optimal

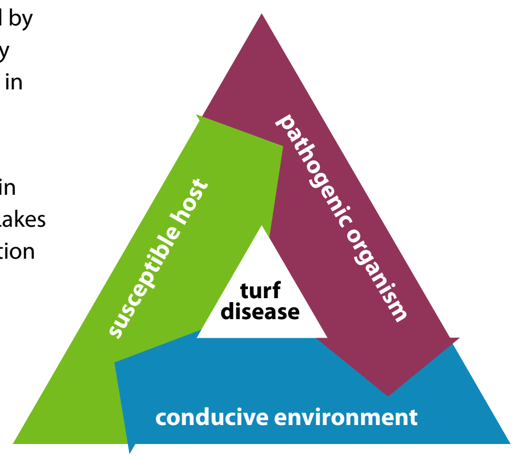


FIGURE 5. Disease triangle. For diseases to occur there must be a susceptible host plant, a pathogenic organism, and a conducive environment all present at the same time.

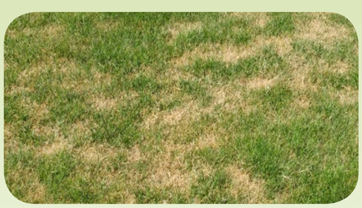
Some common diseases of turfgrass in Wisconsin

red thread

speckled snow mold

powdery mildew

fairy ring



summer patch

slime mold

temperature range, and knowing if recent conditions have been exceptionally warm or cold, and whether there has been a prolonged period of moisture or high humidity, can help identify the correct disease. Lastly, identify any obvious cultural problems present on the site. If the turf is in a heavily shaded area or in a poorly draining soil, it may predispose the plants to fungal infection and provide an indication of what disease(s) may be present.

Accurate disease diagnosis can still be difficult even when each of the above steps is followed. Failure to accurately identify the problem can lead to wasted use of a fungicide and continued expansion of the symptoms. The **Turfgrass Diagnostic Lab** is a nonprofit lab operated by the University of Wisconsin that provides turfgrass professionals with fast and accurate diagnoses and recommendations for any turfgrass-related problem. More information about the lab, including sample submission instructions, can be found at www.tdl.wisc.edu.

Cultural control strategies

A healthy plant is the best defense against pathogen infection, and proper cultural practices are the most effective means of producing a healthy plant. Adjusting cultural practices to optimize plant health will leave the plant better suited to fend off infection.

Site preparation

Proper site preparation can alleviate many problems that lead to increased disease later on. Working up and tilling the soil prior to seeding can reduce soil compaction, which is a contributing factor to root-infecting diseases like necrotic ring spot and summer patch. If the area is chronically wet, installation of subsurface drainage and/or proper surface grading can help move excess water off the site and help lessen numerous diseases from the root-infecting diseases mentioned above to foliar diseases such as red thread, leaf spots, and Pythium blight.

Species/cultivar selection

Turfgrass species vary in their susceptibility to disease. Creeping bentgrass is widely susceptible to many foliar and root-infecting diseases, which is one reason fungicides are routinely used on golf courses. Common lawn species like Kentucky bluegrass and perennial ryegrass can be susceptible to leaf spots, rust, necrotic ring spot, and summer patch. Even species such as fine fescues and tall fescue, which are generally considered more disease resistant, are still susceptible to certain diseases like red thread and brown patch, respectively. In addition, certain species have cultivars with increased levels of resistance. There are Kentucky bluegrass cultivars available with resistance to leaf spot and necrotic ring spot, creeping bentgrass cultivars with resistance to dollar spot, and many other examples. However, most "resistant" cultivars still see some level of disease development in a given year. New cultivars with improved levels of disease resistance are constantly emerging, and you can contact a university extension specialist or turfgrass seed industry representative for the latest information on resistant species and cultivars.

Differentiating diseases from abiotic agents

- Diseases typically progress and spread over time if the infection conditions remain optimal, while abiotic symptoms typically do not spread.
- Diseases typically only affect one species in a mixed stand of turf, while abiotic symptoms oftentimes affect all grass species in a certain area.
- Disease symptoms are usually randomly distributed, whereas abiotic symptoms often form in regular patterns.

Example: Injury from an abiotic agent (e.g., dog urine, photo a) can be similar in appearance to disease (e.g., necrotic ring spot, photo b).

(a) Turf injury from an abiotic agent (dog urine).

(b) Necrotic ring spot, a fungal disease.

Mowing

Mowing removes leaf material from the plant and reduces the plant's ability to produce energy. Excessive low mowing decreases the plant's ability to fend off pathogen attacks and can lead to increased rates of certain diseases, especially stress-related diseases such as anthracnose. Though each species has a range of acceptable mowing heights, heights greater than 2.5 inches for lawn turf and ⅛ inch for creeping bentgrass turf generally don't impact disease. Excessive high mowing can lead to turf "laying over" and trapping moisture during the winter months, which can increase severity of certain diseases like pink and gray snow mold. In addition to mowing height, dull mower blades can produce a ragged cut of the leaf blade that can increase water loss and susceptibility to pathogen infection.

Fertility

Nitrogen is the nutrient that most often limits turfgrass growth, and applying additional nitrogen as fertilizer can aid a plant's ability to resist or recover from a disease by improving plant vigor. On the other hand, some diseases are encouraged by excessive nitrogen, presumably attracted to the lush and nutrient-rich leaf material. Diseases such as brown patch, Pythium blight, and snow molds are encouraged by excessive nitrogen while dollar spot, red thread, and rust are common when nitrogen is deficient. While the amount of nitrogen required for healthy turf will vary based on a variety of factors, in general 2 to 4 pounds of nitrogen applied per 1,000 ft^2 throughout the growing season will be sufficient to prevent most diseases. Though less often associated with particular turfgrass diseases, increasing rates of potassium has been shown to increase pink and gray snow mold severity in creeping bentgrass, annual bluegrass, and perennial ryegrass. Micronutrients such as iron can be used in a fungitoxic manner to suppress dollar spot on golf course putting greens, and manganese has been shown to suppress development of patch diseases like take-all patch and summer patch.

Irrigation

Most fungi require water to infect turfgrass, so prolonged periods of wet leaves or excessively wet soil can encourage disease development. Diseases that are particularly severe in wet conditions include red thread, leaf spot, brown patch, Pythium blight, Microdochium patch, and summer patch. The amount of water required by the turf to remain healthy will vary widely based on turf species, cultural practices, and environmental conditions. In general, it is best to keep the turf as dry as possible without observing drought stress symptoms such as wilting or "footprinting." If irrigation is required to supplement natural rainfall, it should be conducted in the early morning hours when possible to minimize evaporative losses and to prevent prolonged periods of leaf wetness that could occur if the turf was irrigated in the evening hours. In-ground irrigation systems in home lawns, parks, and athletic fields should be used in conjunction with weather data and not on an automatic timer to prevent irrigation from occurring during periods of heavy and/or frequent rainfall.

Shade

Insufficient sunlight leads to weakened turf due to a lack of photosynthetic energy production. However, turfgrass in shade is also more susceptible to many foliar diseases because of limited air movement, which leads to longer durations of leaf wetness. Most foliar diseases will be more common on shaded turf, including powdery mildew, leaf spot, red thread, and dollar spot. Shade stress can be minimized by trimming or removing trees and other barriers to sunlight. In addition, shade-tolerant turf species such as fine fescues and tall fescue will be less susceptible to disease development in the shade than other species like creeping bentgrass or Kentucky bluegrass. For more information on growing grass in shade, consult UW-Extension publication A3700, *Growing Grass in Shade*.

Thatch management

Thatch is a layer of partially decomposed organic residue and living tissue that often forms near the soil surface in turfgrass systems. The dense concentrations of organic matter make this layer an optimal home for many fungal pathogens, especially those causing root-infecting diseases like necrotic ring spot and summer patch. Thatch in excess of 0.5 inch (0.1 inch on golf course putting greens) can harbor fungal pathogens and increase disease severity. In addition, a thick thatch layer can prevent water and nutrients from reaching the soil and lead to increased disease as a result of water and nitrogen deficiencies. Excessive thatch is most effectively prevented through proper nitrogen fertilization, irrigation, and drainage. Thatch that is present is most effectively reduced through regular core aeration once or twice during the fall. In addition, regular applications of sand topdressing can be used to manage thatch development on golf course putting greens.

Soil compaction

Compacted soil does not necessarily increase the activity of fungal pathogens, rather it stunts turfgrass root growth as a result of impeded air and water penetration into the soil. Consequently, plant health declines and disease resistance is lowered. Soil compaction is particularly associated with root diseases such as necrotic ring spot, summer patch, and take-all patch and stress-related diseases such as anthracnose. In areas of high traffic, core aeration can be conducted one or twice during the fall to alleviate the compacted soils.

Soil pH

Most turfgrass diseases are able to develop at any pH typically encountered in turfgrass systems. However, diseases such as summer patch, necrotic ring spot, and take-all patch are favored when soil pH is 7.8 or higher. Some evidence suggests that anthracnose is more severe at lower pH (less than 6.5), but in general most turf performs best in soils with a pH between 5.5 and 8.2. Though adjusting soil pH through management practices can be difficult or impossible depending on the soil type and environmental conditions, applications of an ammonium sulfate (or other sulfur-based) fertilizer can be effective in slightly reducing soil pH, while applications of lime can be effective in slightly increasing soil pH.

Biological control strategies

Biological control agents are living organisms that are used to prey on disease pathogens or outcompete them for nutrients and/or space on the plant. They are desired for their low toxicity to nontarget organisms, however, there are few biological control products commercially available that are effective in controlling turfgrass diseases. Past biological control products that have been developed for use in turfgrass have oftentimes been ineffective, expensive, and/or impractical to use. Research in this area is increasing and may lead to more effective products in the future.

Chemical control strategies

For the most up-to-date information on which fungicides are most effective against the appropriate pathogen(s), visit the Turf Pest Management website (https://turfpests.wisc.edu).

Diseases observed on most home lawns, athletic fields, and sod production facilities in Wisconsin rarely kill large swaths of turfgrass. As a result, routine fungicide use is rare in these areas. On intensively managed golf course turfgrass, however, disease pressure is high enough that fungicides may be routinely required to maintain acceptable turfgrass quality. It should be noted that even on intensively managed golf courses, proper cultural management of the turf is essential for acceptable disease control. Fungicides should be used to supplement a disease management program, and should not be the only or even the most important part of that program.

TABLE 4. Advantages and disadvantages of preventive vs. curative fungicide applications.

	Advantages	Disadvantages
Preventive	• No disease occurs • Use lower fungicide rates compared to curative • Reapply at longer intervals compared to curative	• If conditions aren't conducive for disease development, then more fungicide was unnecessarily applied
Curative	• Can result in less overall fungicide used compared to preventive when conditions aren't favorable for disease development	• Disease symptoms are present at the time of application • Use higher fungicide rates compared to preventive • Reapply at shorter intervals compared to preventive • May encourage development of fungicide resistance

Preventive vs. curative applications

Fungicides can be applied either on a preventive basis (prior to disease appearance) or on a curative basis (after disease appearance) (table 4). Preventive applications are typically used when there is a high degree of certainty a disease will cause damage on a given site or when the tolerance for any disease present is very low. Predictive weather models and past site history aid in the application of preventive fungicides. Curative applications are typically used when diseases are not commonly observed at a particular site or when a certain amount of disease can be tolerated.

Phytomobility

The knowledge of how a fungicide moves on and within the plant after it has been applied is important for its proper use (table 5). Also referred to as the topical mode of action, it is important in determining how long the fungicide remains active (i.e., its residual), whether it should be used on a preventive or curative basis, and whether it will be susceptible to the development of fungicide resistance.

TABLE 5. Phytomobility.

Phytomobility	Residual	Description	Advantages	Disadvantages
Contact	7–14 days	Acts like a protective coating on the outside of the plant	• Fast-acting • Low resistance risk • Broad spectrum of disease control	• Short residual • Excellent coverage required • Doesn't protect newly emerging leaves
Localized penetrant	14–21 days	Absorbed into the leaf but only transported short distances	• Longer residual than contact • Transported short distances in the plant • Can limit fungal infections inside leaf	• Coverage still important for efficacy • Concerns about fungicide resistance
Acropetal penetrant	14–28 days	Absorbed into the plant and only transported upwards in the plant xylem	• Longest residual • Can move long distances inside plant • Can limit fungal infections inside leaf	• Sometimes slow to act • Concerns about fungicide resistance
True systemic	14–28 days	Absorbed into both the xylem and phloem, transported both up and down in the plant	• Can move both up and down in the plant	• Only one true systemic fungicide in turf (Fosetyl-Al)

Fungicide resistance

Repeated use of fungicides with the same biochemical mode of action (i.e., the manner in which the fungicide kills the fungus) can contribute to buildups of fungicide resistant populations. Though application of fungicides are not believed to cause the individual mutations that lead to fungicide-resistant fungi, repeatedly using the same fungicide will select for individual fungal isolates in the population that are already resistant and allow them to grow and spread within the population. Most contact fungicides have multiple modes of action so resistance is not likely to occur with these products. Systemic fungicides, however, usually have only one mode of action and are often prone to development of fungicide-resistant populations.

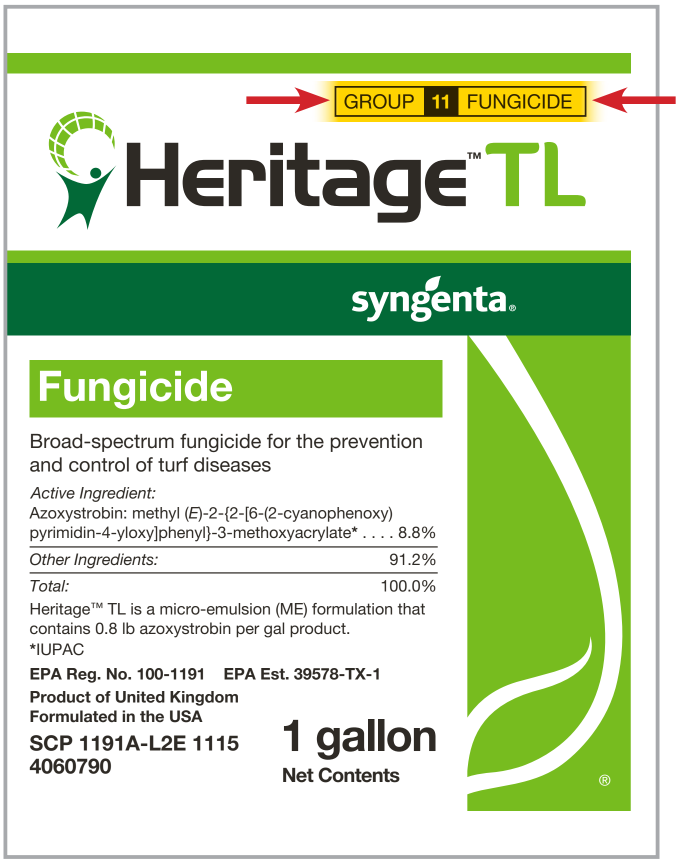


FIGURE 6. Fungicide label with FRAC code. Fungicides containing the same Fungicide Resistance Action Committee (FRAC) code are in the same chemical class. To rotate between fungicide classes for the purpose of resistance management, always rotate or tank-mix fungicides with different codes. The FRAC code can be found on the top of the front page of most fungicide labels.

Label courtesy of CDMS.net.

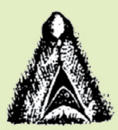
Minimizing fungicide resistance

- Alternate or tank mix fungicides from different chemical classes, and never make more than two consecutive applications of fungicides from the same class.
- Use Fungicide Resistance Action Committee (FRAC) codes present on the front of most fungicide labels to help determine which products are in what class (figure 6).
- If a FRAC code is not present on the label, visit the FRAC website (www.frac.info) to determine which chemical class your fungicide is in.
- Alternate or tank mix with contact fungicides that have multisite modes of action such as chlorothalonil, fluazinam, or mancozeb.
- Never apply at a rate below the lowest recommended label rate.
- Use fungicides as part of an integrated pest management plan to limit the number of fungicide applications made in a given year.

VERTEBRATE PEST MANAGEMENT

FIGURE 7. **Common (or eastern) mole.**

Wisconsin is fortunate to have a rich diversity of wildlife, but at times some of these species can cause problems in managed turf areas. When turf damage occurs, it is critical to spend an appropriate amount of time identifying with reasonable confidence the damage-causing species. Correctly identifying the animal(s) will help in understanding the laws or regulations that must be followed, and in selecting the most effective management practice to reduce or eliminate the damage.



Common (or eastern) mole.

Star-nosed mole.

Moles

Moles are small mammals that are closely related to shrews. There are two species of moles that cause damage to turf in Wisconsin: the common (also referred to as the eastern) mole (*Scalopus aquaticus*) (figure 7) and the star-nosed mole (*Condylura cristata*). The common mole is found in the western ⅔ of the state and in upland, well-drained soils, while the star-nosed mole occupies moist soils in the northern ⅔ of Wisconsin. Moles feed primarily on earthworms and insect larvae.

FIGURE 8. **Mole hills in turf.**

Damage

Damage primarily occurs when the soil is not frozen and moles are actively looking for food just beneath the turf surface. As moles move through the soil they create raised tunnels that appear as ridges (figure 8). In the winter, they burrow deeper into the soil to escape temperature extremes. The only evidence of the deeper burrows are the mounds of soil pushed up to the surface. The entrance to a mole burrow is a conical mound of soil (i.e., volcano-shaped) and is often plugged with soil. Gopher holes, although similar in size, are conical on three sides but the fourth side appears "fan-shaped."

Monitoring

One must first determine which mole tunnels are active. This can be accomplished by pressing down on the raised soil on some of the straight runs. If the tunnel is re-excavated after a day or two, the mole is likely present.

Control

Trapping is the best method for controlling moles in turf. Several commercially available traps have been designed specifically to catch moles. These traps include the harpoon trap, the choker trap, and the claw-like trap.

There are several other methods for controlling moles. These include baits containing toxicant or reduction or elimination of food sources by using pesticides or biological controls like beneficial nematodes. Other home remedies claiming to kill moles are often unproven or ineffective.

For additional information, refer to UW-Extension publication G3997-003, *Mole Ecology and Damage Management*.

Voles

Voles are a type of rodent and are often confused with mice. There are four species of vole found in Wisconsin, but the species most likely to cause damage to turf is the meadow vole (*Microtus pennsylvanicus*) (figure 9), found throughout the state. Populations of voles may fluctuate from year to year, which influences the level of damage they cause.

Damage

Much of the damage caused by meadow voles results from the girdling of bark from trees and shrubs. Damage is most common in the winter when food supplies are limited and the voles are protected from predators while burrowing beneath the snow. Voles can damage turf by clipping the grass close to the roots as they construct surface runways beneath the snow. However, turf damage is typically temporary and disappears once the grass begins growing in the spring.

Monitoring

The best time to monitor voles is in the fall prior to snowfall. Look for the voles as well as surface runways in the grass, fresh grass clippings, and feces.

Control

If voles are present in large enough populations and control is warranted, several control options are available. Cultural control tactics such as frequent and close-cut mowing will limit damage and reduce the amount of available cover. Encouraging the presence of natural predators such as hawks, owls, foxes, skunks, weasels, and snakes can also be an effective biological control tactic. In areas where vole populations are not extensive or you are trying to control voles in a small area such as a residential yard, mouse traps baited with peanut butter can be an effective control method. Make sure to place the trigger of the trap in the surface runway.

FIGURE 9. **Meadow vole.**

FIGURE 10. **Gopher.**

Gophers

The gopher, also called the pocket gopher (*Geomys bursarius*) (figure 10), is a burrowing rodent that is generally restricted to west-central Wisconsin and is more problematic in rural areas. Other than during mating season and raising young, much of a gopher's life is spent alone and underground. Although gophers are relatively inactive during the winter, they do not hibernate.

Damage

Gopher damage is most severe when the soil is not frozen and they are active near the soil surface. They feed on plants, including roots, seeds, and bulbs. Mounds and holes can pose a problem for humans and animals walking and may impede mowing equipment. A fan-shaped mound of excavated soil and a plugged tunnel entrance are good indicators as to the culprit.

Control

Gophers are usually difficult to control. Barriers and traps are effective physical control measures, but can be difficult to implement because gophers can burrow deep into the soil. Gophers are vulnerable to predators such as dogs, cats, raccoons, weasels, foxes, badgers, coyotes, and hawks. Gopher baits are available. One type of bait is strychnine-based and another bait contains the active ingredient zinc phosphide. Gopher baits must be used carefully to avoid nontarget poisoning. Strychnine and zinc phosphide are restricted-use pesticides in Wisconsin, meaning you are required to be certified as a pesticide applicator to purchase and use these chemicals.

Ground squirrels and chipmunks

The thirteen-lined ground squirrel (*Spermophilus tridecemlineatus*) (figure 11), also referred to as the striped gopher in Wisconsin, and the eastern chipmunk (*Tamias striatus*) are burrowing rodents common to urban and rural landscapes. Thirteen-lined ground squirrels inhabit most of Wisconsin except for the northern edge of the state, while chipmunks can be found throughout Wisconsin. The burrowing and feeding activity of ground squirrels and chipmunks can cause substantial damage to turf as well as landscape and garden plants. Both species breed in spring and remain active through October, at which time they enter their burrows to hibernate.

Damage

Ground squirrels prefer grassy areas such as parks, lawns, and playgrounds. Chipmunks can also be found in grassy areas but also inhabit deciduous and coniferous forests. Both types of animals are most active on bright, sunny days and feed on seeds, roots, and insects, among other food sources. Similar to moles and gophers, ground squirrels and chipmunks dig and reside in burrows.

Monitoring

Ground squirrels and chipmunks rarely leave excavated soil near the burrow entrance. However, it is fairly easy to identify the burrow entrance as both species' burrow entrance is approximately 2 inches in diameter and surface runways also measure roughly 2 inches wide. Ground squirrels and chipmunks are active during the day and are often seen outside their burrows.

FIGURE 11. Thirteen-lined ground squirrel.

Control

Excluding ground squirrels and chipmunks using hardware cloth can be effective to protect ornamental seeds and bulbs. After planting, lay hardware cloth directly on top of the soil and then stake down and topdress the hardware cloth with a thin layer of soil. The cloth should extend at least one foot past each margin of the planting. Exclusion may be impractical in cases where the burrowing rodents can dig under or climb over the excluded area.

Place ground squirrel and chipmunk attractants like landscape plants (bushes, trees, and low-lying plants) and bird feeders away from areas you wish to protect.

Using rat traps next to burrow entrances may reduce chipmunk and ground squirrel populations in situations where rodent populations are not extensive or the area of damage is relatively small. Rat traps can be purchased at local hardware stores and garden centers. A variety of baits can be used to lure chipmunks and ground squirrels into traps including peanut butter, nutmeats, and pumpkin or sunflower seeds.

Natural predators such as hawks, snakes, fox, coyotes, and badgers may help to suppress populations. Creating, enhancing, or maintaining habitat for predators of ground squirrels and chipmunks can attract these animals to your area.

For additional information, refer to UW-Extension publication G3997-011, *Chipmunk and Ground Squirrel Ecology and Damage Management*.

Skunks

Striped skunks (*Mephitis mephitis*) (figure 12) are members of the weasel family. Found throughout the state of Wisconsin, skunks are generally considered beneficial because they feed primarily on insects such as crickets, grasshoppers, beetles, cutworms, armyworms, and other insect larvae. Skunks will also feed on small mammals such as mice, rats, shrews, moles, and ground squirrels, as well as vegetables, fruits, and bird eggs. They are primarily active from early evening through most of the night. Skunks are less active during winter months, but they do not hibernate.

Damage

Aside from their odor and potential disease risk as a carrier of rabies, the most common damage they cause results from digging when foraging for food. Skunks dig holes in lawns or roll up small sections of sod to look for white grubs. The holes are typically small (2 to 3 inches in diameter) and cone-shaped. The rolled-up areas can be 3 to 6 inches wide and up to 2 feet long.

Monitoring

Skunks are rather easy to detect by both sight and smell. Signs of skunk include their scat and tracks. Skunk scat is usually ¼ to ½ inch in diameter and 1 to 2 inches long, with undigested insect parts inside. Skunk tracks have five toe prints with visible claw marks on both the fore- and hind feet. Hind feet marks are generally around 2.5 inches long and show a distinct heel pad.

FIGURE 12. Striped skunk.

Control

Modifying your habitat to make it less attractive to skunks is the most effective way to prevent the animals from invading your property. Always seal garbage cans, dispose of any additional food sources skunks may use, and eliminate any possible shelter (such as woodpiles or an open tool shed). Elimination of natural food sources can minimize the likelihood of skunk damage in turf. For example, controlling white grubs reduces potential food resources for skunks to feed. For more information on controlling white grubs in home lawns refer to UW-Extension publication A3275, *Turfgrass Disorder: White Grubs*.

Excluding skunks from your residence or outbuildings can effectively solve the problem with little to no contact with the animal. Seal off foundation openings with concrete, mesh, or sheet metal and cover window wells.

Live trapping a destructive skunk using a medium-sized trap baited with a can of cat food or sardines is easy and effective. Place the trap where signs of skunk activity are present and open the trap during nighttime hours. By law, an open trap must be checked at least once every 24 hours. Before you relocate an animal, you must get permission from the property owner or manager to release it on property you neither own nor occupy.

Carbon dioxide gas cartridges can be inserted in skunk dens on property you own to kill any animals present. Fumigants should not be used for dens that share proximity to an occupied building because the gas could seep into living quarters and potentially poison human occupants. Always follow directions on the fumigant label. All openings to the den need to be sealed to contain both the skunk and fumigant. After the area is rid of skunks, fill in the den to prevent other animals from using it.

For additional information, refer to UW-Extension publication G3997-009, *Skunk Ecology and Damage Management*.

University of Wisconsin-Extension

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