Regulatory Pest Management

A Guide for Commercial Applicators
Category 9

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A Guide for Commercial Applicators Category 9

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Image Sources

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Regulatory Pest Management

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Introduction

How to Use This Manual

This manual contains information needed to become a certified commercial applicator in Category 9, Regulatory Pest Management. This manual is intended to be used in combination with the *Pesticide Applicator Core Training Manual* (Extension Bulletin E-2195), available through the Michigan State University Bulletin Office or most MSU Extension county offices.

Category 9, Regulatory Pest Management, covers the management and control of pests regulated by state or federal laws. Applicators in this category are usually state or federal government employees working with a regulatory pest control program. Regulatory activities may include quarantine, monitoring, trapping, suppression, or eradication of pests.

The category 9 certification exam is based on information found in this manual. Each chapter begins with a set of learning objectives that will help you focus on what you should understand from each chapter. The table of contents helps you identify important topics and understand how they relate to one another. As you prepare for the exam, read each chapter and answer the review questions found at the end of each chapter. An answer key is located at the end of the manual. These questions are not the same questions as found on the exam, but are designed to help you prepare for the exam. All questions on the exam will come from reading material found in the manual.

This certification manual benefits the applicator and the public. By learning how to handle pesticides correctly and how to decide when pesticide applications are warranted, applicators can protect themselves, others, and the environment from pesticide misuse.

For more information on how to become a certified applicator in Michigan, refer to the beginning of the core manual (E-2195) or the Michigan Department of Agriculture's web site, [http://www.michigan.gov/mda], or call the MDA at 1-800-292-3939.

CHAPTER

1

Introduction to Regulatory Pest Management

LEARNING OBJECTIVES

After completely studying this chapter, you should:

- Understand what a regulated pest is.
- Understand how exotic pests are introduced.
- Understand how pest spread can occur following introduction.
- Understand how the dynamics of the environment impact pest spread.
- Specific life cycles of the pest to be managed and appropriate management techniques.
- The potential impact of pesticide applications to non-target areas or organisms.
- General public notification procedures.

INTRODUCTION

Commercial pesticide applicators in regulatory pest management include state, federal, or other government employees or contractors who use pesticides in the management of regulated pests. The state of Michigan has established the following standards for certification in Category 9, Regulatory Pest Management:

> Applicators shall demonstrate a practical knowledge of regulatory pest management including all of the following:

This manual contains information on all of the above plus additional information relevant to regulatory pesticide applicators. Chapter 1 provides an overview of what regulatory pest management is and the factors that contribute to the introduction, spread, and establishment of new pests. Chapter 2 covers the basic strategies used in regulatory pest management programs. In Chapter 3, you will learn about the laws and regulations that affect regulatory programs. Chapter 4 covers the potential impact of pesticide applications on non-target organisms and the environment as well as general public notification procedures. Finally, Chapter 5 presents regulatory pest life cycles and management techniques.

REGULATORY PEST MANAGEMENT

The objective of regulatory pest management is to prevent the introduction and/or spread of pests through the application of various pest management techniques such as pest exclusion, detection, eradication, mitigation, and public education. Achieving this objective requires limiting movement of commodities and materials, and treating commodities, materials, and the environment.

An organism can become a regulated pest when it interferes with:

- Health.
- Comfort.
- Leisure.
- Aesthetic satisfaction.
- Recreation.
- Stability of existing biological systems.
- Agricultural and material production.

Organisms that may be considered pests include:

- Insects.
- Fungi.
- Bacteria.
- Viruses.
- Nematodes.
- Weeds.
- Vertebrate animals.
- Other organisms as defined by the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) as amended.

Regulatory pest management measures may be taken if:

- The pest poses an actual or expected threat.
- The objective is reasonably attainable.
- The economic gains outweigh the costs of application of control measures.

PEST INTRODUCTION AND SPREAD

An organism that is not a serious pest in its native environment can become a devastating pest when introduced into a new environment. Often the natural controls that are present in the pest's native environment are not present in the new area, allowing the pest to flourish. Any organism that is introduced to a new, non-native location, and is likely to cause economic or environmental harm or harm to human health is called an **exotic pest.**

It is important to distinguish between natural spread and artificial spread of pests.

Natural spread is movement that the pest is capable of without assistance of people. Some pests may be capable of moving only short distances each year, while others may spread long distances by the movement of wind, water, and birds or other wildlife. In general, quarantines are not effective at controlling the natural spread of pests. For example, winged insects and some pathogens can be spread great distances on wind currents. Some soil-borne pests can be transported over long distances in water. Natural barriers such as oceans, deserts, and mountain ranges can slow natural spread.

Artificial spread of pests is the movement of pests by people via aircraft, buses, ships, trains, trucks, and automobiles. Modern shipping methods can allow pests to travel quickly and arrive at their destination in a viable condition. Preventing the artificial spread of pests is a primary objective of regulatory pest control programs.

It is not possible to intercept every exotic pest. Introductions can occur by way of infested or infected agricultural commodities imported into the country.

Pests can be transported to new locations through boxes or crates used for shipping many different types of products.

Pests can also be found in non-agricultural products such as within boxes or crates used for shipping many different types of products. The emerald ash borer was likely introduced through infested pallet material. Ships can introduce pests such as the zebra mussel through the dumping of ballast water. Ships infested with pests such as Asian gypsy moth could have adults moths fly from the ship toward lights on shore without ever docking at a port.

Regulatory programs are designed to reduce the movement of infested materials to a low level so that the likelihood of an exotic pest becoming established will be minimal, but they are not a guarantee of protection.

POPULATION DYNAMICS

To evaluate the seriousness of an exotic pest threat, it is necessary to understand the environmental requirements of the introduced pest. The environment where the pest has been introduced may be more or less favorable to the pest than its native habitat. The exotic pest may have more or fewer predators and parasites in the new environment. The new location may be more or less favorable in terms of environmental conditions.

Factors in the Establishment of a Pest

The arrival of an organism in a new area does not guarantee it will successfully establish itself. A number of factors determine if the organism will become an established pest, including:

- **The introduction must be into an area with a suitable environment.** For example, if the organism is killed by freezing temperatures, it is not likely to become an established outdoor pest in Michigan.
- **The introduction must be into an area with a suitable host.** If the new organism feeds only on species that are not found in the new area, it will not survive. If the new organism requires alternate hosts, both hosts must be present in the new area and occur in the proper sequence for successful establishment of the pest.
- **The introduction must include viable pests in sufficient numbers to allow for reproduction and spread**.

Factors in a Regulatory Control Program

When developing a regulatory control program, many factors should be considered including:

- Population densities.
- Reproduction and mortality rates.
- Age distributions.
- The pest's vigor.
- The potential for growth and spread of the pest given the new environmental conditions.

Control or eradication programs must evaluate all life stages of the introduced pest to identify vulnerable life stages. It is necessary to know what effects factors such as pesticides, parasites, predators, and host resistance have on all life stages of the new pest. A pesticide that only kills one stage of a pest may decrease a population temporarily but will not decrease the population over the long term if other measures are not taken to control other life stages.

Studies of the introduced pest's life cycle can often identify critical life stages and other factors that are important in producing significant population changes. By recognizing these key factors, we can develop control measures that can have a significant impact on reducing the population.

Researchers and regulators must work together to develop an effective exotic pest management program.

CHAPTER 1

REVIEW QUESTIONS

Chapter 1: Introduction to Regulatory Pest Management

Write your answers to the following questions and then check your answers with those in the back of the manual.

1. What is the objective of regulatory pest management?

2. Which statement is true regarding regulated pests?

   A. Regulated pests include insects and vertebrate animals but not bacteria or fungi.

   B. Pests that interfere with public health or recreation may become regulatory pests but not those that interfere with aesthetics.

   C. All exotic pests are regulatory pests.

   D. Regulatory measures to control a pest may be taken if the pest poses an actual or expected threat.

3. What is the definition of an exotic pest?

4. Which statement is true regarding the spread of pests?

   A. Artificial spread occurs when pests move by wind, water, birds or other wildlife.

   B. A primary objective of regulatory pest management is to prevent the natural spread of pests.

   C. Shipping is a relatively slow means of transportation; therefore, pests are rarely brought in on ships.

   D. It is not possible to intercept every exotic pest.

5. What are the three factors that favor the establishment of an exotic pest?

6. Why is it important to have a thorough understanding of an introduced pest's life cycle when setting up a regulatory pest control program?

CHAPTER

2

Elements of a Regulatory Program

LEARNING OBJECTIVES

After completely studying this chapter, you should:

- Understand the basic strategies of regulatory pest management.

INTRODUCTION

The public agricultural agencies in the United States have a mission to protect agriculture, the environment, and citizens from the economic and environmental harm caused by pests. Preventing pests while also providing for equitable and orderly domestic and international trade is a major challenge.

The goal of a pest prevention program is to prevent the introduction, colonization, and establishment of pests that would cause significant agricultural, environmental, and/or societal harm in an area where the pest does not already occur. The program must efficiently and effectively:

- Identify pest harm.
- Assess pest risk.
- Manage pest risk.

Successful plant and animal pest control depends on the successful blending of many skills. Regulatory pest management programs use several different strategies which may include:

- Identification of risk.
- Prevention of entry.
- Survey and detection.
- Eradication.
- Retardation of spread.
- Mitigation of losses.

As a pest becomes established one strategy is generally replaced by the next strategy.

Throughout the program the following are important components:

- Pest diagnostics and record-keeping.
- Public information and education.

IDENTIFICATION OF RISK

Before prevention strategies are initiated, pest prevention agencies must be able to:

- See the possibility for harm.
- Determine the probability for harm.
- Take appropriate avoidance measures.

A pest risk analysis is used to determine the probability for harm. Regulatory agencies look at the pests already present in the area; the life cycles and host ranges of quarantine pests of concern; when, where, why and how harm could occur and to what degree; how the pest could be introduced; and the likelihood of colonization and establishment.

The pest risk analysis may identify a quarantine pest. An organism may become a quarantine pest if:

- It is a pest.
- It could cause significant harm.
- It is likely to be moved artificially into or already exists in the endangered area and is being or would be officially controlled.
- It could survive in the endangered area.
- The risk could not be reduced to an acceptable level by means other than regulation.

Damage caused by introduced pests can be devastating as seen in this forest defoliated by gypsy moth.

Once the risk is identified, the cost(s) associated with preventing the probable level of harm are evaluated to determine if the cost is worth the benefits. If the effort is determined to be worth the cost, then a pest prevention program is initiated.

PREVENTION OF ENTRY

The primary strategy to exclude pest entry is through the use of quarantines. Quarantine inspection programs at ports of entry are designed to prevent the introduction and establishment of pests into the United States. Inspectors work cooperatively with other border inspection agencies in the examination of passengers, baggage, and vessels of transport. Certain agricultural products are restricted from entry unless accompanied by documentation to verify freedom from pests. Other agricultural products are prohibited from entry when disinfestation techniques are not available or are not effective at controlling potentially harmful pests.

Inspections help prevent the introduction of pests into new areas.

Quarantines in and of themselves are generally not 100% effective at excluding exotic pests. However, a quarantine can be effective at reducing the incidence of pest introduction and reduce any incidents of introduction to a manageable population that can be eradicated.

SURVEY AND DETECTION

For effective management of exotic and invasive pests to occur, we must first be aware of the existence of the pest. Early detection and rapid response are essential to an effective and cost-efficient pest control program. Often, non-native pests become established without anyone noticing. The public may not express concern until the pest is widespread and is causing visible problems. By this time, control measures can be costly and largely ineffective.

Survey and detection is also important when pests penetrate the pest exclusion barrier and become established. The goal of pest detection is to discover infestations while they are still small enough to eliminate. Several types of surveys and detection trapping programs are conducted to accomplish this.

It is important for regulatory staff to be aware of pests that occur in their area and to investigate situations where they find plants, insects, diseases or animals that they do not recognize as belonging in the area. Inspectors who see unusual plant damage or mortality should attempt to determine the cause of the damage. Problems of an undetermined nature could be caused by a non-native pest. Where previously unknown pests are found, the information must be reported to the appropriate regulatory agency. Inspectors should submit a sample of the pest and/or pest damage when possible and provide complete documentation regarding the situation.

Once an exotic pest is found, additional visual surveys and/or trapping programs are performed to determine if an infestation exists; and, if so, how extensive it is. Surveys help determine the feasibility of eradication. Surveys are also needed to identify the areas where eradicative treatments and quarantine measures need to be applied.

Survey and trapping programs help identify the scope of the infestation and indicate where treatments and quarantine measures should be taken.

University researchers and extension agents, pest control advisors and operators, farmers, and the public support formal detection surveys and trapping programs by reporting unusual pests, diseases, and abnormalities discovered in the normal course of their business or private activities.

ERADICATION

If prevention is not successful and an introduction occurs, the immediate objective of the control program is to eradicate the pest. Eradication generally means using all available viable options, which often includes the application of pesticides. Other pest control measures may include elimination of the pest's food source in the limited area where the outbreak has occurred, or changing the pest's habitat so that the pest can not survive. Mass trapping can be a useful tool in helping reduce populations. Use of mating disruption techniques such as spreading flakes impregnated with pheromones can be another useful tool.

Eradication can be drastic as this removal of trees infested with Asian longhorned beetles in Chicago shows.

Eradication efforts must be implemented quickly and decisively to achieve the goal of eliminating the pests. The goal of eradication can be difficult to achieve because small populations of the pest can sometimes survive the eradication efforts in numbers not easily detected by surveys. Over time, these small populations can reproduce and may cause significant damage or spread through artificial means to a variety of areas. It is important to monitor for the presence of the pest after the goal of eradication is thought to have been achieved to assure that the pest has actually been eliminated.

RETARDATION OF SPREAD AND MITIGATION OF LOSSES

If the pest becomes firmly established and eradication is not feasible, the next practice is to slow or prevent the spread and to mitigate losses. Quarantines can be effective at slowing the spread of pests. Inspections and pest control treatments may help to reduce the spread. Treatments to slow the spread of the pest and to mitigate losses in the infested area might include:

- The use of pesticides.
- The release of parasites or predators.
- The release of sterile mates.
- The removal of the host.
- The use of varieties that are resistant to the pest.

PEST DIAGNOSTICS AND RECORD-KEEPING

Timely and accurate pest diagnostics is extremely important for a successful pest prevention program. Specimens and samples collected in the performance of the exclusion and detection work need to be quickly identified by trained personnel. Record-keeping is also very important because interception and detection records are essential for making valid and meaningful pest pathway studies, risk analyses, and quarantine evaluations.

PUBLIC INFORMATION AND EDUCATION

Effective pest prevention programs require an educated and supportive public. The public must know what quarantine restrictions exist and why they exist in order to be motivated to comply with them and to support funding for them.

An educated and supportive public is extremely important to slow the spread of pests and prevent introductions. Inspecting a toy for gypsy moth eggs (left) and firewood infested with emerald ash borer (right).

Unfortunately, this element of pest prevention is often underfunded and neglected. This component is becoming even more important as international commerce increases and more and more people travel to foreign locations for business and recreation.

CHAPTER 2

REVIEW QUESTIONS

Chapter 2: Elements of a Regulatory Program

Write your answers to the following questions and then check your answers with those in the back of the manual.

1. What is the goal of a pest prevention program?

2. Why is it important to do a pest risk analysis before initiating a pest prevention program?

Match the following pest management strategies with the appropriate description.

A. Quarantine
B. Survey and Detection
C. Eradication

_____ 3. Generally means using all available pest management options.

_____ 4. May involve the use of traps to identify the scope of the infestation.

_____ 5. The primary means of preventing pest entry.

_____ 6. Effective at reducing the incidence of pest introduction.

_____ 7. Important for recognizing when a plant, insect, disease, or animal is present in an area it does not belong.

_____ 8. May involve eliminating the pest's food source.

9. List five treatments that may be used to slow the spread of a pest that can not be eradicated.

10. Why is it important to have accurate pest diagnostics and record-keeping?

11. Why is it important to inform and educate the public about pest prevention programs?

CHAPTER

3

Laws and Regulations

LEARNING OBJECTIVES

After completely studying this chapter, you should:

- Understand state and federal laws that provide statutory authority to regulate pests.
- Understand mechanisms used in the regulation of pests including quarantines, inspections and pest surveys.
- Understand pesticide labeling and exemptions.

INTRODUCTION

Laws and regulations at both the state and federal levels give authority to regulate pests. These provide the state and federal government with the authority to:

- Establish quarantines to prohibit or restrict the movement of certain agricultural products from foreign countries into the United States, or from one state into another state.
- Provide export documentation for domestic products when requested by interested parties.
- Provide for post-entry inspection of quarantined plants that have been brought into Michigan under an import permit requiring that the plants be quarantined for a specific amount of time.
- Establish programs to eradicate or suppress certain pests. These may be exotic pests or indigenous harmful pests.

These acts and the regulations provide the foundation for a flexible program for protecting the United States and individual states against exotic and indigenous harmful pests.

LEGISLATIVE AUTHORITY

Both federal and state governments have the authority to enact and enforce laws and regulations pertaining to nuisance pests. It is important for regulatory pest managers to be familiar with both the federal and state laws and to know which quarantines are enforced within Michigan.

Federal Programs

Federal regulatory programs for plant health protection are provided for by congressional act or under authorities granted to the Secretary of

Agriculture, and through delegated authority to the United States Department of Agriculture's (USDA) Animal and Plant Health Inspection Service (APHIS). APHIS regulates the importation and interstate shipment of nursery and greenhouse stock and other agricultural products in an effort to minimize the spread of harmful pests.

The federal ***Plant Protection Act of 2000*** consolidated 10 different USDA plant health laws into one comprehensive law that provides authority to regulate plants, plant products, certain biological control organisms, noxious weeds, and plant pests. The Plant Quarantine Act, the Federal Plant Pest Act, the Organic Act, and the Federal Noxious Weed Act are among the ten statutes that the new act replaced.

Some of the provisions under this act include:

- The Secretary of Agriculture may prohibit or restrict the importation, entry, exportation, or movement in interstate commerce of any plant, plant product, biological control organism, noxious weed, or article if this action is necessary to prevent the introduction into the United States or the dissemination of a plant pest or noxious weed within the United States.
- The Secretary of Agriculture may hold, seize, quarantine, treat, apply other remedial measures to, destroy, or otherwise dispose of any plant, plant pest, noxious weed, biological control organism, or plant product to prevent the dissemination of any plant pest or noxious weed new to or not known to be widely prevalent or distributed within and throughout the United States. The least drastic action will be taken to accomplish this goal.
- The Secretary of Agriculture may issue regulations requiring that any plant, plant product, biological control organism, noxious weed, or article imported, entered, to be exported, or moved in interstate commerce:
  1) Be accompanied by a permit issued prior to the importation, entry, exportation, or movement in interstate commerce.
  2) Be accompanied by a certificate of inspection by appropriate officials of the country or state from which the plant, plant product, biological control organism, noxious weed, or article is to be moved.
  3) Be subject to remedial measures to prevent the spread of plant pests or noxious weed.
  4) Be grown or handled under post-entry quarantine conditions to determine whether the plant or biological control organism may be infested with plant pests or may be a plant pest or noxious weed.

Federal Quarantines

Plant pest quarantines are imposed to prevent artificial introduction or to limit the spread of pests. Quarantines can restrict the production, movement, or existence of plants, plant products, animals, animal products, or any other articles or material, or activity of people which could result in the artificial introduction or spread of the specified pest(s).

The following list includes some of the important federal quarantines existing at the time this manual was last updated in July 2005.

- Asian longhorned beetle
- Emerald ash borer
- Gypsy moth
- Chrysanthemum white rust
- Plum pox
- Sudden oak death

Chrysanthemum white rust is among the pests under federal quarantine.

The National Plant Board publishes the Federal and State Plant Quarantine Summaries, which provides detailed information pertaining to the shipping requirements for certain plants and/or

agricultural products to various states, Puerto Rico, and the District of Columbia. This information can be found at the National Plant Board website at: [http://www.aphis.usda.gov/npb].

State Programs

Michigan, like other states, has authority through agreements with the federal government to enforce federal laws. Michigan also has authority under state law to enact and enforce state quarantines for nuisance pests not covered by a federal quarantine. Michigan's authority to enact state quarantines is derived from **Public Act 189**, the **Insect Pest and Plant Disease Act** and is enforced by the Michigan Department of Agriculture (MDA).

The **Insect Pest and Plant Disease Act** allows Michigan to:

- Prevent the introduction into and the dissemination within the state of insect pests and plant diseases through enactment of quarantines.
- Regulate the sale and distribution of nursery stock, plants, and plant products.
- Eradicate and control harmful insect pests and plant diseases.
- Require any person, firm, partnership, association or corporation that receives living plant parts capable of propagation from a foreign country to contact the MDA on the arrival of such shipment.

State Quarantines

Michigan's Insect Pest and Plant Disease Act allows the MDA to establish quarantines to protect the state from nuisance pests. The state may issue quarantines against harmful pests for which there is a reasonable cause to believe that the potential for the nuisance to exist occurs and for which there is no existing federal quarantine. The state of Michigan may establish an **exterior quarantine** that is designed to restrict movement of pests into Michigan. Michigan currently has several exterior quarantines in effect which include:

- Scleroderris canker quarantine
- Geranium plume moth quarantine
- Hemlock woolly adelgid quarantine

Michigan has an exterior quarantine in effect for hemlock woolly adelgid.

Michigan may also establish **interior quarantines** which regulate movement of pests within the state. There is currently an interior quarantine in Michigan for the emerald ash borer.

Other states also establish their own state exterior quarantines. If someone wishes to transport material into another state, he or she must follow the quarantines established by that state.

In addition to a federal quarantine, there is also an interior quarantine in Michigan for the emerald ash borer.

A state may also regulate non-quarantine pests. These are often referred to as **"quality pests."** In Michigan, the Insect Pest and Plant Disease Act gives authority to the Michigan Department of Agriculture to make sure that plants being shipped are "apparently free of pests." Some of the most common quality pests are found in Chapter 5.

Export Inspections

The best safeguard against the spread of pests is to control the pest in the country or state of origin. Shippers sending agricultural products from the United States to a foreign country or from Michigan to another state may be required to provide officials in the receiving area with specific documentation. These documents may include items such as a **state** or **federal phytosanitary** (clean plant) **certificate** attesting to freedom from certain pests. Similarly, persons attempting to bring certain agricultural products into the United States or into Michigan from other areas may need to provide regulators with phytosanitary certification attesting to freedom from certain pests known or suspected to be found in the point of origin.

State phytosanitary certificates or other documentation such as a **certificate of quarantine compliance** or **limited permit** may be required to facilitate interstate shipment of agricultural products such as Christmas trees or nursery stock to certify freedom from pests. Before these shipping documents can be issued, state or federal inspectors may be required to verify that certain pest control treatments have occurred. Often these treatments include the use of pesticides. Verification may require the inspector to be on-site at the time the treatment is conducted. During the verification process, inspectors may encounter products or areas that have been treated with pesticides and must be aware of the dangers associated with these exposures so that appropriate personal protection can be used.

Some export inspections may require verification that the product has undergone an appropriate fumigation treatment. Inspectors who need to be on-site to verify that the treatment was done should be knowledgeable in fumigation practices. Michigan State University publishes a manual (Extension Bulletin E- 2579) for commercial and private applicators to help them obtain a fumigation standard with their certification credential. It is advisable for inspectors to obtain the fumigation standard on their certification credential if they will be working in areas where fumigation is occurring.

Import and Post-entry Inspections

Some plant species are susceptible to pests, including virus diseases, which can cause death or a serious reduction in plant vigor and crop yields. Plant viruses can be difficult or nearly impossible to detect during the dormant life stage of the plant. Some viruses can be latent in nature and take more than one growing season before the plants develop symptoms.

To help reduce the incidence of these types of diseases, a person importing plants from a foreign country must obtain a permit from USDA's APHIS. When the plants arrive at US Customs, they are subject to inspection. Plants which pass the US Customs inspection may enter the United States, but some may be held under a **post-entry quarantine** as specified on the import permit.

Plants held under a post-entry quarantine are subject to inspection in accordance with a specified schedule before the plants can be released for use or sale. Some stock, such as stock susceptible to viruses, will be required by the import permit to be held at a specified location and will be subjected to a series of inspections over a given time period. The post-entry inspection period is usually two years, but may be longer if necessary. The grower is required to hold all plant material on site until released or destroyed by the certifying official.

In accordance with Public Act 189, anyone receiving plants or plant parts capable of propagation from a foreign country shall notify the MDA of the arrival on such shipment and shall hold the shipment not more than 10 days, within such time that the shipment will be duly inspected or released by the MDA. State officials may inspect the imported stock or may release the stock without further inspection where the pest risk is minimal.

Plant Grower and Nursery Stock Grower Inspections

Michigan's Insect Pest and Plant Disease Act requires that herbaceous perennials and woody nursery stock be inspected at least once each year

during the growing season to ascertain whether they are infested with insect pests or infected with plant diseases. Stock found to be infested or infected with harmful pests are restricted until the pest problem is corrected.

Inspections may be conducted on plant products or sites that have been treated with pesticides. Inspectors should contact the grower to inquire about any recent pest control applications and any applicable **re-entry intervals (REI).** In general, inspections should not be conducted until the REI is expired, but there may be instances when inspections are conducted prior to the expiration of the REI.

Inspectors should be aware that the federal Worker Protection Standards (WPS) requires specific ventilation requirements prior to entry into a greenhouse treated with pesticides. There are specific REI requirements that apply to nursery areas in general as well. Inspectors should refer to the federal WPS regulations for details on re-entry information. Inspectors must have a thorough understanding of appropriate personal protective equipment and utilize the equipment to protect themselves from exposure to potentially harmful pesticides.

Exotic Pest Survey

Michigan's Insect Pest and Plant Disease Act provides that the MDA may conduct monitoring activities to survey for the presence of exotic pests. An **exotic pest** is a pest that is not native to the United States.

The MDA conducts routine monitoring for non-indigenous pests known to occur in Michigan, such as gypsy moth. Pests like gypsy moth are widespread across the state and surveys are done for the purpose of monitoring the pest's spread and development to aid in coordinating suppression activities.

The MDA also monitors for the presence of non-indigenous pests such as Japanese beetle, which are found in some parts of the state, but not in others. These surveys are conducted to monitor the spread of the pest. Shipments of certain products may be restricted from movement if coming from an area known to be infested and being shipped to a non-infested area.

The MDA also conducts surveys for pests such as plum pox virus, which is not known to occur in the state at the time this manual was published. Surveys are conducted for pests such as plum pox because of the potential for infestation by this devastating disease. If an exotic pest such as plum pox is detected, the MDA can take quick and decisive action to prevent the further spread of the pest.

While surveying for exotic pests, inspection staff may be required to place traps that utilize pesticides or to collect vegetative samples that may have been treated with pesticides. Staff must be aware of the potential hazards of working with these pesticides and take appropriate precautions to protect themselves and others. When conducting surveys on grower sites, the inspector should contact the grower to get information about any pesticides that may have been applied to the crop.

PESTICIDE LABELS AND EMERGENCY EXEMPTIONS

The most important law regulating pesticide registration, distribution, sales, and use in the United States is the Federal Insecticide, Fungicide and Rodenticide Act, or FIFRA. The Environmental Protection Agency (EPA) and the Michigan Department of Agriculture (MDA) administer FIFRA.

Pesticide labels provide information on proper use, application rates, sites where the pesticide can be applied and the target pests for control. Labels also contain information on protecting the applicator, the environment and the crop from harmful effects of pesticides while providing effective control of target pests. Pesticide labels are legal documents that applicators must follow. Always read the entire label and all supplemental labeling before using a pesticide.

Supplemental labeling includes any information you receive from the manufacturer about how to use the product. Supplemental labels may include Special Local Needs labels (24c), Emergency Exemption labels (Section 18) as well as additional use information issued by the pesticide manufacturer. The supplemental label is considered part of the

pesticide label and may be supplied at the time of purchase or requested from the dealer. If an applicator applies a pesticide according to a supplemental label, a copy of the supplemental label must be in the applicator's possession at the time of application.

Always:

- Select pesticides labeled for use on your crop.
- Read and understand the label instructions and limitations before each use.
- Follow the application directions on the pesticide label.
- Contact your county MSU Extension office if you have questions or concerns about a particular pesticide.

If a new pest is introduced, it is possible that sufficient quantities of an appropriately labeled product are not available or no pesticides are registered to control the pest. The Federal Insecticide Fungicide and Rodenticide Act (FIFRA) provides authority to the United States Environmental Protection Agency (EPA) to exempt any state or federal agency from any provisions of FIFRA if an emergency condition exists. Several methods of exemptions are available including APHIS manuals, 24 (c) registration, and Section 18 labels.

APHIS Manuals

In order to facilitate the use of pesticides for regulated pests, it is possible to have APHIS manuals considered a part of the pesticide product labeling by adding to the label a statement similar to the following:

> "Also for use in accordance with the recommendations and instructions issued by the United States Department of Agriculture for quarantine programs. To be used only by or under the direction of federal/state personnel for quarantine treatments."

24(c) Registration

Under the authority Section 24(c) of FIFRA, states may register additional uses of a federally registered pesticide to meet "special local needs" as long as there is a demonstrated "special local need" and a tolerance, exemption from a tolerance, or other clearance under the Federal Food Drug and Cosmetic Act. The Michigan Department of Agriculture has authority to issue special local needs registrations [also known as SLNs or 24(c) registrations] for the state of Michigan. Once issued by the state, EPA reviews these registrations and can request that the state revoke the registration if it was improperly issued. Applicators must have the 24(c) supplemental label in their possession at the time of application.

Section 18 Labels

Section 18 of FIFRA allows the EPA to exempt state and federal agencies from any provision of FIFRA if it is determined that an emergency condition exists that requires an exemption. An emergency condition is an "urgent, non-routine situation that could not have been reasonably anticipated" and "will have dire consequences if the exemption is not granted." The exemptions usually allow use of a pesticide on a site for which it is not federally registered. Extensive data input is required. Section 18 labels are valid for one growing season and must be renewed annually. MDA is required to conduct follow-up inspections regarding use and efficacy of the product. Users must obtain a copy of the Section 18 label to use the product.

CHAPTER 3

REVIEW QUESTIONS

Chapter 3: Laws and Regulations

Write the answers to the following questions and then check your answers with those in the back of the manual.

1. According to the Plant Protection Act of 2000, what are the four possible requirements imposed on plants, plant products, biological control organisms, and noxious weeds being imported, exported, or moved interstate?

2. Federal quarantines can restrict the production, movement, or existence of plants, plant products, animals, animal products, or any other articles or material, or activity of people which could result in the artificial introduction or spread of the specified pest(s).

   A. True.

   B. False.

3. Michigan does not have the authority under state law to enact and enforce state quarantines for nuisance pests not covered by a federal quarantine.

   A. True.

   B. False.

4. Describe the state of Michigan exterior quarantine versus an interior quarantine.

5. When might a state or federal phytosanitary certificate be required?

6. What is required before issuing a certificate of quarantine compliance or limited permit for the shipment of agricultural products?

7. What is the purpose of the post-entry quarantine?

8. According to the Insect Pest and Plant Disease Act, how often must herbaceous perennials and woody nursery stock be inspected in Michigan?

   A. At least once each year during the growing season.

   B. At least twice each year during the growing season.

   C. At least once during the growing season and once during the dormant season.

   D. At least twice during the dormant season.

9. The state of Michigan does not attempt to monitor for plants not known to occur inside the state.

   A. True
   B. False

10. What is supplemental labeling? Give an example.

11. In the event a new pest is introduced and there is no product labeled to control it, what documentation to supplement the label may be used to allow control of the pest?

CHAPTER 4

Using Pesticides in Regulatory Programs

LEARNING OBJECTIVES

After completely studying this chapter, you should:

- Understand the concepts upon which a pest control method is selected.
- Understand the difference between point and non-point-source pollution.
- Understand management practices to reduce groundwater contamination.
- Understand how to protect non-target organisms from pesticides.
- Understand how pesticide resistance develops and how to delay or prevent resistance.
- Understand the requirements for notification when using pesticides in a regulatory program.

PESTICIDE SELECTION AND CONTROL METHODS

A successful regulatory program relies on a variety of factors to control pests. Of primary significance is the use of quarantines to control pests at the point of origin. However, as discussed in the preceding chapters, quarantines may not be 100 percent effective at eliminating pest introductions. Once an introduction occurs, other control measures become essential.

Pesticide Selection

Use of pesticides when pest populations are newly established and not widely distributed is generally economically feasible and a biologically sound practice. The selection of an appropriate method of application and pesticide product is based on a variety of considerations including:

1. What are the vulnerable life stages of the pest? Will the pest come into contact with the pesticide? Does the pest feed during the targeted life stage? Is the pest protected by its location—for example, is it burrowed into the soil or into the trunk of a tree?
2. Can the host species be targeted with a pesticide? Is the host species in a location suitable for pesticide applications?
3. What method of pesticide application will be effective? Options include aerial applications, fumigation, animal dip vats, soil, or tree injections, etc.
4. What formulation of pesticide will be safe and effective? Options include baits, gas,

emulsifiable concentrates, wettable powders, dusts, water dispersible granules, aerosols, etc.

5. What is the pesticide's mode of action? Options include fumigants, contact poisons, stomach poisons, systemic poisons, soil sterilants, etc.
6. What is the size and location of the treatment area? Large areas may necessitate aerial application. If the pest's targeted life stage is the larval stage of a wood-boring insect, then injection or soil application may be needed.
7. What is the effect of the pesticide on the target and non-target organisms? If the pesticide is moderately effective at controlling the pest, but has an adverse effect on other non-target organisms, then the applicator may need to utilize other treatment options.

When selecting a pesticide, consideration should be given to the following:

1. Utilize an effective pesticide that is as selective as possible against the target pests and has the least impact on non-target species.
2. Utilize a pesticide that can be used at the lowest effective amount per unit area.
3. Look for pesticides that will not persist in the environment any longer than that which is needed to control the pests.
4. Look for pesticides that can be applied in a safe and effective manner, without causing problems associated with drift or contamination of non-target areas. Drift can result in unintended consequences such as adversely affecting non-target organisms. Pesticides that drift onto non-target sites not only waste pesticide material, but may waste the resource of time and money needed to deal with the issue of drift. Most pesticides are labeled in a way that directs the user not to drift from the target site. State law directs users to avoid drift. Therefore, drift not only presents a public relations problem, it is illegal.

Other Control Methods

In addition to quarantines and the use of pesticides, other measures can be employed to control or eradicate exotic pests.

Biological controls may be introduced to control introduced pests. For example, purple loosestrife is an invasive non-native plant and several important beetles have been introduced to help control the spread of this pest, including the loosestrife leaf beetle *(Galerucella calmariensis)* and the root-boring weevil *(Hylobius transverovittatus)*. Gypsy moth is another introduced pest whose populations can be greatly reduced following introduction of a fungus *(Entomaphaga maimaiga)* which kills gypsy moth caterpillars.

The loosestrife beetle *(Galerucella calmariensis)* has been used for biological control of purple loosestrife.

Great care must be taken to study the potential adverse effects of introducing a new exotic species to control an introduced pest. The risks and benefits of the controls must be carefully weighed and studied to ensure that the species introduced for control does not become a pest in its own right.

If the targeted pest is contained within a limited geographic area, **elimination of the pest's food source and/or habitat** can be an effective tool. For example, if a nursery grower received a shipment of hemlock infested with hemlock woolly adelgid (a non-indigenous pest not known to occur in Michigan), one control measure could be to eliminate all the hemlock within that nursery and to monitor or eliminate any nearby hosts to prevent further spread of any escaped adelgids.

If it is not feasible to eliminate the pest's food and/or habitat because the size of the infestation is too large, another option to consider is creation of a **buffer zone** around the infested area. The pest's food source and/or habitat within the buffer zone could be

eliminated, preventing the further spread of the pest. Efforts can then be concentrated on eliminating the pest within the contained zone.

Pest control programs conducted by regulatory personnel are often under public scrutiny and staff must take great care to ensure that pesticides are used safely and effectively. The public should be informed as to the scope of the pest problem being controlled, the measures being taken to control the pest (including pesticides as needed), and the risk and benefits of using pesticides in the control program. Some people may have a belief that all pesticides poison the environment. The public should be made aware that the use of pesticides does not necessarily result in an adverse effect on the environment. The careful selection and judicious use of pesticides can result in environmental benefits. In other situations, the use of pesticides can result in neutral or indeterminate impacts on the environment.

PROTECTING OUR GROUNDWATER

Groundwater is the water beneath the earth's surface. It is found in the cracks and pores of rocks and in the spaces between sand grains and other soil particles. Many people living in rural Michigan get their drinking water from groundwater brought to the surface by wells. It is easy to see why you should be concerned about keeping pesticides out of groundwater.

Groundwater is always moving. Eventually, it reaches the earth's surface at natural places such as lakes, springs, and streams. Sometimes it is pumped to the surface from wells. Every year, rain and snow seep into the soil, replenishing the groundwater. The depth at which you first find groundwater is referred to as the **water table**. The water table depth changes during the year, depending on the amount of water added to and removed from the ground.

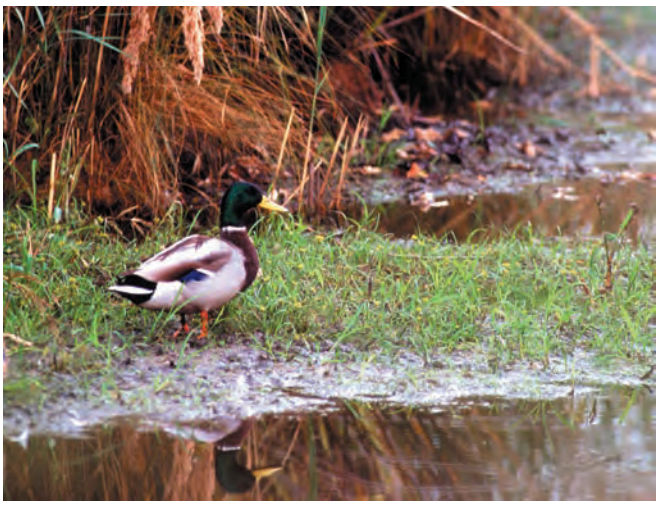
Both **surface water**—visible bodies of water such as lakes, rivers and oceans—and groundwater are subject to contamination by point and non-point source pollution. When a pollutant enters the water from a specific source or location, it is called **point-source pollution**. For example, a factory that discharges chemicals into a river is a point source. **Non-point-source pollution** refers to pollution from a generalized area or weather event, such as runoff, precipitation, acid rain, or percolation rather than from discharge at a single location.

Keeping Pesticides Out of Groundwater and Surface Water

A pesticide that has not become a gas (**volatilized**) or been absorbed by plants, bound to soil or broken down can potentially migrate through the soil to groundwater. Groundwater movement is slow and difficult to predict. Substances entering groundwater in one location may turn up years later somewhere else. A difficulty in dealing with groundwater contaminants is discovering the pollution source when the problem is occurring underground, out of sight. Also, microbial degradation and photodegradation (by sunlight) do not occur deep underground, so pesticides that reach groundwater break down very slowly. Cleaning contaminated groundwater or surface water is extremely difficult. Following certain practices can reduce the potential for pesticide contamination of groundwater and surface water:

- **Use integrated pest management**. Keep pesticide use to a minimum.
- **Consider the geology of your area** when locating wells, mix/load sites or equipment washing sites.
- **Be aware of the water table depth** and how fast water moves through the geological layers between the soil surface and the groundwater.
- **Select pesticides carefully**. Choose pesticides that are not likely to leach (move downward) in the soil into groundwater or run off into surface water.
- **Be aware of pesticides that are very water-soluble.** Pesticides that are not easily bound to soil and are water-soluble tend to be the most likely to leach.
- **Read pesticide labels carefully**, consult the MSU Extension pesticide application guides, or seek advice from an MSU specialist or a pesticide dealer to choose the best pesticide for your situation.

- **Follow pesticide label directions**. Container and supplemental pesticide labels are the law. Labels provide crucial information about application rates, timing, and placement of the pesticide. Consult all labels before using the pesticide.
- **Calibrate accurately**. Calibrate equipment carefully and often to avoid over- or under-application.
- **Measure accurately**. Carefully measure concentrates before placing them into the spray tank. Do not "add a little extra" to ensure that the pesticide will do a better job.
- **Avoid back-siphoning**. Make sure that the end of the fill hose remains above the water level in the spray tank at all times. This prevents **back-siphoning** of the pesticide into the water supply. Use an **anti-backflow device** when siphoning water directly from a well, pond or stream. Do not leave your spray tank unattended.
- **Consider weather conditions**. If you suspect heavy rain will occur, delay applying pesticides.
- **Mix on an impervious pad**. Mix and load pesticides on an approved impervious mix/load pad where spills can be contained and cleaned up. If mixing in the field, change the location of the mixing area regularly. A portable mix/load pad is required if you fill at the same location 10 or more times per year.
- **Dispose of wastes and containers properly**. All pesticide wastes must be disposed of in accordance with local, state, and federal laws. Triple-rinse or pressure rinse containers. Pour the rinse water into the spray tank for use in treating the labeled site or crop. After triple rinsing, perforate the container so it cannot be reused. Recycle all metal and plastic triple-rinsed containers or dispose of them in a state-licensed sanitary landfill. Dispose of all paper containers in a sanitary landfill or a municipal waste incinerator. Do not burn used pesticide containers. Burning does not allow for complete combustion of most pesticides, resulting in pesticide movement into the air; it is also a violation of state regulations administered by the Michigan Department of Environmental Quality. Contact your regional MDA office or local county Extension office for information on pesticide container recycling in your area.
- **Store pesticides safely and away from water sources**. Pesticide storage facilities should be situated away from wells, cisterns, springs, and other water sources. Pesticides should be stored in a locked facility that will protect them from temperature extremes, high humidity, and direct sunlight. The storage facility should be heated, dry, and well ventilated. It should be designed for easy containment and cleanup of pesticide spills and made of materials that will not absorb any pesticide that leaks out of a container. Store only pesticides in such a facility and always store them in their original containers.



Wetlands can be very vulnerable to contamination from pesticides.

PROTECTING NON-TARGET ORGANISMS

The best way to avoid injury to **beneficial insects and microorganisms** is to minimize the use of pesticides. Use selective pesticides when possible. Apply pesticides only when necessary and as part of an integrated pest management program.

Bees are extremely important for the pollination of fruit crops. Many insecticides are highly toxic to bees. Take the following precautions to reduce the chance of bee poisoning:

- **Do not treat near beehives**. Bees may need to be moved or covered before you use pesticides near hives.

- **Select the least hazardous pesticide formulation and lowest toxicity if bees are present**. Dusts are more hazardous to bees than sprays. Wettable powders are more hazardous than emulsifiable concentrates (EC) or water-soluble formulations. Microencapsulated pesticides are extremely dangerous to bees because the very small capsules can be carried back to the hive. Granular insecticides are generally the least hazardous to bees.

The choice of pesticides and timing of application can greatly reduce the effect on bees.

- **Do not apply pesticides that are toxic to bees if the site contains a blooming crop or weed**. Remove the blooms by mowing before spraying.
- **Minimize spray drift** by selecting appropriate nozzles, adding an adjuvant or postponing the application to a less windy time.
- **Time pesticide applications carefully**. Evening applications are less hazardous than early morning ones; both are safer for bees than midday applications.

Pesticides can also be harmful to **vertebrates** such as fish and wildlife. Fish kills may result when a pesticide (usually an insecticide) pollutes water or changes the pH of the water. Pesticides may enter water via drift, surface runoff, soil erosion, or leaching.

Pesticides may result in bird kills if birds ingest granules, baits or treated seed; are exposed directly to the spray; drink and use contaminated water; or feed on pesticide-contaminated prey.

Endangered and threatened species are of special concern. Under the federal Endangered Species Act, every pesticide posing a threat to an endangered or threatened species or to its habitat must have a warning statement on the label. The statement may instruct the applicator to consult a county bulletin that provides instructions on how to safeguard the species when using the pesticide within its habitat. The EPA is developing the county bulletins as part of the Endangered Species Protection Program.

Care should be taken to prevent harm to birds, fish, and other wildlife.

POTENTIAL FOR PESTICIDE RESISTANCE

Pesticide resistance is a measurement of a pest's ability to tolerate the toxic effects of a particular pesticide. Intensive use of a product may allow only resistant individuals to survive. As the number of resistant individuals increases in a pest population, the original application rate or spray frequency no longer provides adequate control.

The Development of Resistance

Repeated applications of the same pesticide or of pesticides with a common mode of action give

a pest population a chance to develop resistance. **Resistance** is an individual's (weed, crop, insect, etc.) ability to survive a specific pesticide application. There are three mechanisms of resistance. Resistant individuals:

- May have a modified site of action so that the pesticide is no longer toxic.
- Metabolize (detoxify) the pesticide. **Metabolism** is a biochemical process that modifies the pesticide to less toxic compounds.
- Remove the pesticide from the site of action.

Resistant individuals have the genetic ability to survive when the pesticide is applied and their offspring inherit the pesticide resistance. Because the pesticide kills most of the non-resistant individuals, the resistant organisms over time make up an increasingly larger percentage of the surviving pest population. With each use of the pesticide, this percentage increases until most of the pests are resistant and the chemical is no longer effective against the pest.

In most cases, pests that are resistant to one pesticide will show resistance to chemically related pesticides. This is called **cross-resistance**. Cross-resistance occurs because closely related pesticides kill pests in the same way—for example, all organophosphate insecticides kill by inhibiting the same enzyme in the nervous system, cholinesterase. If a pest can resist the toxic action of one pesticide, it can often survive applications of other pesticides that kill the same way.

Resistance Management

Resistance management attempts to prevent or delay the development of resistance. A resistance management program includes:

- **Using integrated pest management**. Combine cultural, mechanical, biological, and chemical control measures into a practical pest management program. For example, crop rotation can reduce the buildup of pests in a particular crop and so reduce the number of pesticide applications needed. This reduces the advantage that resistant individuals have over non-resistant individuals and delays or prevents the buildup of resistance in a population.
- **Using pesticides from different chemical families with different modes of action**. Try to do this whether you apply pesticides against a pest once a year or several times within a treatment season.
- **Using pesticides only when needed, and using only as much as necessary to effectively maintain control.**

DRIFT MANAGEMENT

Good public relations are extremely important when applying pesticides. It is the joint responsibility of landowner and applicator to see that neighboring landowners are not subjected to acts of trespass or exposed to spray drift. As a matter of courtesy, it is a good idea to inform adjacent landowners, neighbors, and beekeepers in advance of any large-scale pesticide application.

If off-target pesticide drift is expected, Michigan Regulation 637 requires a pesticide applicator to have a **drift management plan**. A drift management plan should contain:

- A map of all areas where pesticide applications occur.
- A list of pesticide-sensitive sites located near an application area—for example, schools, daycare facilities or sensitive crops.
- Pesticide label and mandated restrictions that relate to setback provisions from sensitive areas.
- Information for persons in sensitive areas regarding the type of pesticide used, the method of application and the applicator's plan to minimize pesticide drift.

A drift management plan should be used by private and commercial applicators as a communication tool to minimize adverse effects of off-target drift. For more information on drift management plans, contact the Michigan Department of Agriculture.

NOTIFICATION

Michigan law requires commercial applicators to provide notice for certain types of pesticide applications as follows:

Turf and Ornamental Sites

In accordance with Regulation 637, Rule 11(2), when making a broadcast, foliar, or space application of a pesticide to a turf or ornamental site, other than a golf course or farm production operation, an applicator shall post the primary point(s) of entry to the treatment area with appropriate markers. The signs must be at least 4 inches high by 5 inches wide, constructed of sturdy weather-resistant materials, attached to a supporting device to extend at least 12 inches above the ground, and be printed in green letters on a white background with the following information:

- The statement "CAUTION" in 72 point type.
- The statement "Pesticide Application" in 30 point type.
- The statement "Keep Off Until Dry" in 30 point type.
- Have not less than a 2-inch diameter circular illustration depicting an adult and child walking a dog on a leash. The illustration shall depict, using a diagonal line across the circle, that this action is prohibited.
- The statement "Customer: Please remove after 24 hours" in 11 point type.

Community or Right-of-way Sites

In accordance with Regulation 637, Rule 11(5), a commercial applicator shall not make a broadcast or foliar application of pesticides for community or right-of-way pest management without making reasonable efforts to provide prior notification to persons who own or reside on property that is within the target area or to their authorized representative.

Reasonable efforts to notify property owners, their agents, or persons who reside within the treatment area for community or right-of-way pesticide applications include at least one of the following methods:

- Personal contact
- Advertisement in at least one newspaper of general circulation within the area of application. The notice shall be placed in the legal advertisement section.
- Prior written notification.

When providing notice for community or right-of-way applications, notification to property owners shall include all of the following information:

- The name, address, and phone number of the application firm or individual.
- The brand name and active ingredient(s) of the pesticide(s) used.
- The method of application.
- The scheduled date(s) of application.
- The name, address, and phone number of a contact person who is responsible for supplying updated information concerning the application for those people who request it.
- Any re-entry restrictions.

Following treatment of a community multiple-use area, the applicator must post the following information for not less than 24 hours at the primary point(s) of entry:

- The name, address, and phone number of the application firm or individual.
- The brand name and active ingredient(s) of the pesticide(s) used.
- The date of the application.
- Any re-entry restrictions.

Schools or Day Care Centers

Beginning March 10, 2005, Michigan Act 451, part 83, Pesticide Control, includes the following requirements for pesticide applications at schools and day care centers.

Schools and licensed child care centers must have in place an "integrated pest management program" when pesticide applications will occur inside buildings.

The following notification procedures are required when pesticides are applied to school or child care center properties (indoor and outdoor).

- School and child care administrators must notify parents or guardians annually that they will receive advance notice of a pesticide application. The annual notice must specify two methods by which the advance notice would be given. The

first method must be posting at the entrance to the school or licensed child care, and a second method chosen by the facility may include other posting options, such as a phone call, an e-mail, providing child or student with information to be provided to the parent or guardian, or a posting on the school's or center's website.

- An advance notice must contain certain information about the pesticide including the target pest or purpose, approximate location, date of the application, contact information at the school or licensed child care, and a toll free number for a national pesticide information center recognized by MDA.
- Parents or guardians must also be informed that they are entitled to receive the notification by first-class mail postmarked three days before the application, if they so request, and the manner in which such a request is made.

Liquid spray or aerosol insecticide applications may not be performed in a room of a school or child care center unless the room will be unoccupied by students or children for not less than four hours or longer if required by the pesticide label use directions. The IPM and notification requirements do not apply to common cleaners such as germicides and disinfectants. Notification requirements do not apply to bait or gel pesticide formulation.

CHAPTER 4

REVIEW QUESTIONS

Chapter 4: Using Pesticides in Regulatory Programs

Write the answers to the following questions and then check your answers with those in the back of the manual.

1. Which would be a criterion for selecting a pesticide?
   A. High drift potential.
   B. Persistant in the environment.
   C. Selective against the target pest.
   D. Effective at high dosages.

2. List three other methods besides quarantines and pesticides to control exotic pests.

3. The depth at which you first find groundwater is referred to as:
   A. The water table.
   B. Surface water.
   C. An aquifer.
   D. Source point.

4. What are point- and non-point-source pollution?

5. List five ways you can reduce the risk of pesticides contaminating groundwater.

6. Which statement is true regarding protection of non-target organisms from harmful effects of pesticides?
   A. Birds are the only vertebrates susceptible to harm from pesticides.
   B. It may be necessary to consult a county bulletin when applying pesticides that may be harmful to endangered or threatened species.
   C. The best way to avoid inury to non-target organism is to allow the pesticide to runoff into surface water.
   D. Microencapsulated pesticides are the least likely to harm bees.

7. Which is a method for minimizing harmful effects of pesticides to bees?
   A. Choose dust formulations over emulsifiable concentrates.
   B. Apply pesticides when crops are in bloom.
   C. Apply pesticides early in the morning rather than in the evening.
   D. Select low toxicity pesticides.

8. Which statement is true regarding resistance to pesticides?
   A. Resistance develops when the percentage of the resistant pest population increases after each application of a pesticide.
   B. Insects may become resistant to pesticides; weed pests do not develop pesticide resistance.
   C. Resistance is generally not an inherited characteristic.
   D. From a pest management perspective, resistance is a desirable characteristic.

9. What is cross-resistance?

10. List three tactics you should use to prevent or delay resistance in a resistance management program.

11. A drift management plan is required by Michigan law if off-target pesticide drift is likely to occur.
    A. True.
    B. False.

12. List four items to include in a drift management plan.

13. According to Michigan law, which type of application requires posting of the primary points of entry into the treatment area?
    A. A broadcast application at a farm production area.
    B. A broadcast application on a residential site.
    C. A foliar application at a golf course.
    D. A foliar application at a farm production area.

14. When making community or right-of-way applications, what information should be included in the notice to property owners?

15. Which statement is true regarding notification of pesticide applications in schools and day care centers?
    A. Annual notification of pesticide applications to parents and guardians is required by schools but not by day care centers.
    B. Only one method of advance notification of pesticides applications is required.
    C. Parents or guardians that request notification of pesticide applications must be informed by first-class mail at least three days in advance of the application.
    D. Advanced notification by posting of the main entrance of the school or day care center is required only when indoor applications are being made.

CHAPTER

5

Pests of Concern

LEARNING OBJECTIVES

After completely studying this chapter, you should:

- Understand how insects grow and develop.
- Understand the disease triangle and disease cycle.
- Be able to describe the life cycles of major regulatory pests.
- Be able to describe damage caused by each pest.
- Be able to identify management strategies for each pest.

This chapter includes information on the life cycles and management of regulatory pests of concern to Michigan. Certification test questions on regulatory pests will be based on the information found here. There are several excellent websites that link to the most recent regulatory information including quarantines, state specific information, distribution of pests, life cycles and management options. Some of these are:

- **PestTracker**—the public access website of the National Agricultural Pest Information System (NAPIS), the agricultural pest tracking database of the US Department of Agriculture Animal and Plant Health Inspection Service (APHIS) Plant Protection and Quarantine (PPQ) Cooperative Agricultural Pest Survey (CAPS) found at [http://ceris.purdue.edu/napis/index.html].
- **Invasivespeciesinfo.gov—**the gateway to federal activities regarding invasive species maintained by The National Invasive Species Council found at [http://www.invasivespecies.gov].
- **The National Plant Board**—an organization of the plant pest regulatory agencies of each of the states and Commonwealth of Puerto Rico found at [http://www.aphis.usda.gov/npb].
- **Invasive Species Inititative**—a source for invasive species expertise and information at Michigan State University found at [http://www.invasivespecies.msu.edu].

INSECT PESTS

The growth and development of an insect pest influences the type of pest management strategies chosen to control it. Several important regulated insect pests are detailed in this section by the type of quarantine it is regulated under, its status in

Michigan, the damage it causes, how to identify it, its life cycle, and control strategies.

GROWTH

Adult insects have three body sections: head, thorax, and abdomen. Six legs are attached to the thorax. Adults may have no wings or two or four wings. An insect's body is confined in a protective **exoskeleton**. This hard outer covering does not grow continuously. A new, soft exoskeleton is formed under the old one, and the old exoskeleton is shed in a process called **molting**. The new skeleton is larger and allows the insect to grow a little more. The new exoskeleton hardens and darkens in a few hours. After the molting process, which usually takes place in hiding, the insect resumes its normal activities.

DEVELOPMENT

Insects can be divided into groups according to the way they change during their development. The technical term for this change is ***metamorphosis***, which means "change in form." Most insect pests undergo either gradual or complete metamorphosis.

Group 1. Gradual Metamorphosis

Insects developing by gradual metamorphosis hatch from eggs and resemble the adult insects except that the immatures, or ***nymphs***, do not have wings. Nymphs periodically molt, growing larger. After the final molt, nymphs become adults and generally have wings. The hemlock woolly adelgid is a regulated pest that develops by gradual metamorphosis. Nymphs and adults are often found together and usually eat the same food.

A plant bug is an example if an insect with gradual metamorphosis.

Group 2. Complete Metamorphosis

Insects that develop by complete metamorphosis make a radical change in appearance from immature to adult. This group includes all beetles, moths, butterflies, flies, bees, and wasps. In complete metamorphosis, newly hatched insects are called ***larvae***. Grubs, maggots, and caterpillars are all types of larvae. The job of larvae is to eat and grow; they usually molt two to five times during their life cycle. Each larval stage between molts is called an ***instar***. After eating, molting and growing, the larvae change into ***pupae***. A pupa is an immobile stage of insect development. During pupation, the insect's body rearranges itself, resulting in a complete change in form from the larva to the adult insect.

All beetles develop by complete metamorphosis.

CONSIDERATIONS FOR PEST MANAGEMENT

The developmental stages of insects with complete metamorphosis often support rather than compete with each other. It's as if there are two or three completely different animals with different needs and habits instead of a single species. The larvae feed and live in one habitat and sometimes leave that area to pupate a short distance away. The adult emerges and often eats a different food and lives in another area, returning to the larval feeding site only to lay eggs. One example is the Japanese beetle—the larva is a grub that lives underground and eats the roots of grasses and the adult is a beetle that eats leaves, fruit, and flowers.

Species with complete metamorphosis are managed according to the particular life stage. Certain stages of insects are more susceptible than others to control measures. For example, cherry fruit fly larvae feed inside fruit and are protected from sprays. Adults of this pest are much more vulnerable. During the 10-day period after emergence before adults lay eggs, carefully timed sprays can kill the adults before they lay eggs.

The optimum time and part of the life cycle for most effective control varies by pest. The following section discusses the life cycle and behavior of various insect pests.

Asian Longhorned Beetle (*Anoplophora glabripennis)*

Regulated under: federal quarantine.

Status in Michigan: not known to be established in Michigan.

The Asian longhorned beetle (ALB) is an exotic pest native to China, Korea, and Japan. It was discovered in New York in 1996 and in Chicago in 1998. Experts believe that it was accidentally introduced into North America from China in solid wood packing material. It has no known natural predators in the United States, and could pose a very serious threat to hardwood trees here.

Damage: The Asian longhorned beetle attacks many different hardwood species including maple (Norway, sugar, silver, and red), birch, horsechestnut, poplar, willow, elm, ash, black locust, and box elder. The larvae feed in the wood of trunks, branches, and large roots of young and mature trees. The large galleries disrupt the sap flow and weaken or kill the tree. This pest attacks both healthy and weakened trees. Emerging adults leave round exit holes up to 1/2 inch in diameter that may ooze sap and frass.

Identification: The ALB adult is a shiny black beetle with white spots on the upper and lower body and is about one inch long and 3/4 inch wide. It has very long antenna with alternating black and white bands. The ALB adult is similar in appearance to the native pine sawyer beetle, but the pine sawyer beetle is a dull black color and does not have the white dots or white bands on the antenna. ALB larvae are white to yellowish, plump grubs that can be up to 1 1/2 to 2 inches long.

Life cycle: Adult beetles are usually active from May to October, with peak activity in midsummer. Females chew pits in the bark used as sites for depositing eggs. Eggs hatch in 1 to 2 weeks, and the young larvae begin feeding and boring into the wood. Older, larger larvae tunnel deep into the wood, periodically pushing coarse sawdust and fecal matter out of entrance holes. The larvae spend the winter in the tree, pupate and emerge as adults in late spring. It usually only takes one year to go from egg to adult.

Asian longhorned beetle adult, pupa and larva.

Control strategies:

- Regulatory efforts focus on prevention of entry, surveillance, and eradication.
- The most effective way to eradicate this pest is to cut, chip, or burn infested trees, and replace them with non-host trees.
- Researchers are working on new options for managing this pest including chemical and biological control options.

Hemlock Woolly Adelgid *(Adelges tsugae)*

Regulated under: Michigan state exterior quarantine.

Status in Michigan: not known to be established in Michigan.

Hemlock woolly adelgid is an exotic species from Asia and has been in the United States since at least 1924. This serious pest of eastern hemlock and Carolina hemlock is now present from the Smoky Mountains, north to the mid-Hudson River Valley and southern New England. The primary host is

hemlock, with spruce being a possible secondary (alternative) host. It is also present on western and mountain hemlock in the Pacific Northwest, but does not cause serious damage to these species.

Damage: Immature nymphs and adults damage trees by sucking sap from the twigs and by injecting a toxic saliva while feeding. This retards or prevents tree growth causing needles to discolor from deep green to grayish green and to drop prematurely. Most buds also die so very little new growth occurs. The loss of new shoots and needles seriously impairs tree health. Defoliation and tree death can occur within several years.

Identification: Because individual adelgids are very small, the first indication of infestation is usually the discovery of the white, cottony egg sacs. This "wool," slightly smaller than the tip of a cotton swab, can be found on the undersides of twigs in the spring. After hatching, nymphs or crawlers produce white cottony/waxy tufts, which cover their bodies and remain in place throughout their lifetime. In addition to protecting the eggs, the wool helps transport the adelgid by sticking to bird feathers or mammal fur. Wind also carries the wax masses between trees, spreading infestations further.

The hemlock woolly adelgid egg sacs look like small clumps of wool on the undersides of twigs.

Life cycle: Two generations occur on hemlock each year. Adults lay 50 to 300 eggs in cottony masses during March and April. Nymphs or crawlers hatch in April and May. They move to the twigs near the bases of needles, insert their piercing and sucking mouthparts, and stay there feeding until they mature in June. Some of these individuals develop into winged, migratory, asexual adults that move to spruce. The other eggs develop into wingless adults that remain on the hemlock. These adults lay new egg masses that hatch in early June. The new crawlers move to new growth, go through a dormant period, and resume feeding in October. The nymphs feed and develop during the winter and mature by spring.

Control strategies:

- Michigan has a quarantine to prevent this pest from coming in.
- Growers should carefully inspect all hemlocks prior to planting.
- Application of insecticides is currently recommended for controlling this pest. All stages are susceptible. Horticultural oils, which smother the insects, have been very effective. Two thorough applications are often necessary. Other pesticides have also been shown to be effective.
- Researchers are studying the effectiveness of introducing biological control agents including the oribatid mite *(Diapterobates humeralis)* and a tiny black ladybird beetle which are effective predators of this pest in Japan.

Emerald Ash Borer *(Agrilus planipennis)*

Regulated under: federal and Michigan state interior quarantines.

Status in Michigan: established in southeast Michigan.

The emerald ash borer is an exotic pest from Asia that was first discovered in six counties in southeast Michigan in 2002. A native of eastern Russia, China, Mongolia, Taiwan, Japan, and Korea, this was the first discovery in North America. It is believed that it arrived in Michigan from ash solid wood packing material. All North American species of ash *(Fraxinus* spp.) are likely to be suitable hosts for this pest. Mountain ash *(Sorbus* spp.) is not a host.

Damage: Emerald ash borer larvae feed in the cambium between the inner bark and the outer ring of wood. This feeding creates S-shaped galleries that disrupt the transport of water and nutrients within

the tree. Usually the emerald ash borer's presence goes undetected until the trees show symptoms of infestation. Typically the upper third of a tree will die back first, followed by the rest of the tree's decline within the next year. This is often followed by a large number of shoots or sprouts arising below the dead portions of the trunk. The time required to kill a tree can be one to four years depending on the size of the tree.

Clockwise from the top: **emerald ash borer adult, shoots on ash that frequently develop after an attack, the characteristic D-shaped exit hole, and three larval stages.**

Identification: This insect belongs to a group of insects known as metallic wood-boring beetles. Adults are dark metallic green in color, 1/2 inch in length and 1/16 inch wide, and are only present from mid-May until late July. The flat-headed larvae are creamy white in color and are found under the bark. Full-grown larvae can be 1 ½ inches in length. The adult beetles typically make D-shaped exit holes when they emerge. Tissue produced by the tree in response to larval feeding may also cause vertical splits to occur in the bark.

Life cycle: The emerald ash borer appears to have a two-year life cycle in southern Michigan, but may require three years to complete the life cycle in colder regions. Adult emergence begins in May and continues through August, depending on the weather. Adult beetles are most active during warm sunny days. Females can mate multiple times and begin ovipositing individual eggs on the bark surface a few days after mating. Females can lay 60 to 90 eggs during their lifetime. Eggs hatch in 7 to 10 days. The first instar larvae chew into the cambial region, feeding on phloem and the outer sapwood for several weeks, creating S-shaped galleries. The full-grown larvae overwinter in a shallow chamber excavated in the sapwood and begin pupation in late April or early May. They remain in the pupal stage for 1 to 2 weeks before emerging head-first through the D-shaped exit hole that they chew.

Control strategies:

- A state interior quarantine is in effect for many Michigan counties in southern Michigan.
- The Michigan Department of Agriculture began an eradication program in 2003.
- Pest control measures include establishment of quarantine, elimination of host material, and use of pesticides by individual property owners.
- Trees with 50% canopy dieback should be cut down and chipped. Stumps should be ground or treated with a herbicide to prevent new sprouts.
- Systemic insecticides injected in the soil or tree trunk have shown good results. Trunk and foliage sprays have also been used. For up-to-date control options and timing, please check the website [http://www.emeraldashborer.info].

Gypsy Moth (*Lymantria dispar)*

Regulated Under: federal quarantine.

Status in Michigan: European gypsy moth established in Michigan.

The European gypsy moth, a native of Europe, Asia, and North Africa, was brought to Massachusetts by a scientist in 1869. The scientist's experiment to develop a new strain of silk-producing caterpillars failed and some of the gypsy moths escaped. This pest has spread widely since then, and now the European gypsy moth is established in most of the northeastern United States including all counties in Michigan.

The Asian strain of this pest has become established in Germany and other European countries where they hybridize with European gypsy moths. The Asian gypsy moth arrived in the United States in the 1990's on cargo ships from infested areas. These introductions in the U.S. have been successfully eradicated.

Damage: Gypsy moths prefer forest habitats and can cause serious defoliation and deterioration of trees and shrubs. Defoliation severely weakens trees and shrubs, killing them or making them susceptible to diseases and other pests. The European gypsy moth has more than 250 known host plants but prefers oak and aspen. The Asian gypsy moth has a broader range of hosts, more than 400 species of trees, including larch, oak, poplar, alder, willow, and some evergreens.

Clockwise from the top: **a gypsy moth caterpillar, female gypsy moths with egg masses, a male (left) and female (right) Asian gypsy moth.**

Identification: Egg masses are coated with hairs from the abdomen of the female and are tan to gray in color. Egg masses can contain 100 to1,200 eggs. The larvae, hairy caterpillars with five pairs of blue spots and 6 pairs of red spots along their backs, grow 2 to 3 inches long. Female adult moths are creamy white while the males are mottled brown with broad, feathery antennae. Female European gypsy moths do not fly and lay egg masses near the pupal case.

Female Asian gypsy moths are significantly larger, are strong fliers, and are attracted to lights at night. Identification of the Asian gypsy moth strain can be difficult and should be confirmed by a laboratory analysis. One important clue for finding the Asian strain is to monitor the presence of females and/or egg masses around exterior light fixtures.

Life cycle: Gypsy moths overwinter as egg masses. Small black first instar caterpillars hatch in the spring from egg masses laid the previous summer. They produce a thin line of silk behind them that allows them to be carried to new locations by wind. As caterpillars, they are voracious eaters of foliage. As they get older, the feeding is nocturnal and they move down the tree in early morning to rest. The caterpillars pupate in protected sites, like under loose bark or on wood piles. They emerge in July or August as non-feeding adults.

Control strategies:

- Efforts continue to prevent the introduction of the Asian strain into the U.S. and to detect and eradicate any new infestations.
- Michigan is within the federal quarantine area for gypsy moth. Regulatory efforts focus on slowing the spread to other states.
- Pheromone traps can be used to time the emergence and flight of adult male gypsy moths.
- Use of host-specific biological insecticides such as *Bacillus thuringiensis* (B.t.) when the caterpillars are less than one inch long can be extremely effective.
- On smaller scales, egg masses can be manually destroyed in late summer and fall. Sticky bands can be wrapped around the tree trunk to help curtail movement of the caterpillars into the tree canopy.

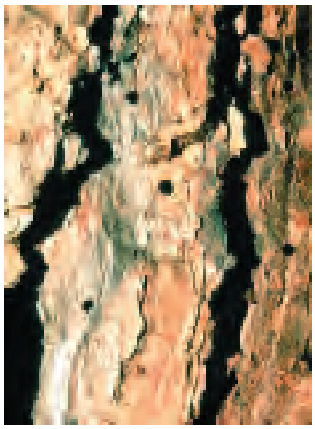
Pine Shoot Beetle *(Tomicus piniperda)*

Regulated under: federal quarantine.

Status in Michigan: established in Michigan.

The pine shoot beetle, an exotic pest of pines native to Europe and Asia, was first discovered in the United States in 1992 near Cleveland, Ohio. It is now found in many states including all counties of Michigan except for the western Upper Peninsula. The beetles are capable of dispersing 2 km in the wind. Artificial spread can occur through the movement of pine Christmas trees, pine nursery stock, bark mulch, and pine logs. A federal quarantine regulates the shipments of pine Christmas trees and other pine products from the counties known to be infested with this pest.

Damage: From May through October, adult beetles feed in tunnels down the centers of the lateral shoots, mostly in the upper half of the crown. Each adult can destroy 1 to 6 shoots. When shoot feeding is severe, tree height and diameter growth are reduced. Scotch pine is the most common host, but other pines can also be hosts.



Clockwise from the top: **an adult pine shoot beetle boring into a shoot, exit holes from newly emerging beetles, a tree with flagging terminal shoots.**

Identification: Adults are reddish brown to black cylindrical beetles, 3 to 5 mm long, about the size of a match head. The larvae are white and legless with a brown head, and are about 5 mm long. From June through December, attacked shoots on live pine trees will have a round hole, often surrounded by a small glob of pitch. Tunnels are hollow and are not filled with frass. Two to five tunnels can be found on one shoot. Attacked shoots eventually die, break off, and drop.

Life cycle: Adult beetles overwinter in niches in the bark at the bases of live pine trees. In the early spring, the adult beetles fly to recently cut or dying pine trees, logs, mulch, or stumps. Adults bore into the inner bark, mate, and females construct egg galleries. Eggs hatch within a few weeks. Larvae feed in the inner bark for 6 to 10 weeks and pupate. New adults emerge in June and fly to current-year or one-year-old shoots where they feed in the shoots until October or November. After frost, the beetles move to their overwintering spots at the bases of live pine trees.

Control strategies:

- Christmas tree growers who ship from infected counties are encouraged to participate in the voluntary Pine Shoot Beetle Compliance Management Program (PSB-CMP). Growers follow a detailed protocol to be "in compliance." The deadlines and details of this program can be found at [http://www.michigan.gov/mda]. The key components include:
  - All potential brood material needs to be destroyed. All pine trees, branches, etc. cut since October 1 of last year need to be piled and burned or chipped.
  - Pine stumps need to be managed to prevent colonization by breeding adults. Stumps can be cut very low, sprayed with an approved insecticide in early to mid-March or in May, or removed and burned or chipped.
  - Trap logs are used to capture adults in search of brood material. Check the website for specific specifications and deadlines for the placement and destruction of trap logs.
  - Cover sprays control the new generation of beetles as they begin to shoot-feed in the summer. The best timing is 400 to 450 degree days base 50.
  - Record-keeping is extremely important.

Japanese Beetle *(Popillia japonica)*

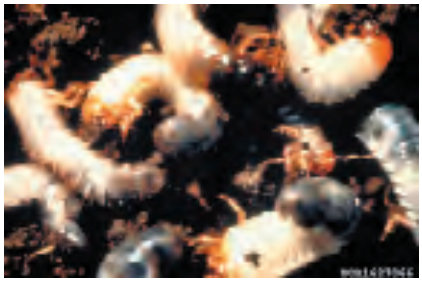
Regulated under: other state exterior quarantines.

Status in Michigan: established in Michigan.

The Japanese beetle was introduced into New Jersey from Japan in 1916. Since that time, it has spread throughout the Atlantic coast and westward, and it is now firmly established in the Midwest.

Damage: The adult beetles skeletonize the leaves leaving only the veins. Damaged leaves eventually shrivel and drop. The adults can also attack flower buds and fruit. Adult beetles can feed on over 300 species of broad-leaved plants, but about 50 species are preferred. The grubs feed on a wide variety of plant roots, most commonly damaging turfgrasses. Damage in turf often resembles drought stress.

Identification: The adult Japanese beetle is less than ½ inch long and has a shiny, metallic-green body and bronze-colored outer wings. The abdomen has tufts of white hairs along its outer edge. The larvae are white grubs that are C-shaped, about 1 inch long with tan heads. They can be distinguished from other white grubs by the V-shaped series of bristles on the hind end.



Adult Japanese beetle (top) and larvae (white grubs).

Life cycle: In general, the Japanese beetle requires only one year to complete its life cycle. Adult beetles usually begin to emerge from the soil during the first week of July with peak beetle abundance occurring about a week later. The beetles remain active until the fall. Eggs are laid in the soil during the summer. After hatching, the larvae or grubs dig to the soil surface where they feed on roots and organic matter. The grubs burrow 4 to 8 inches into the soil when the soil temperature cools and remain inactive through the winter. The grubs return to the surface in the spring when the soil temperature reaches 60 degrees F. They pupate in June and generally emerge from the soil as adults in July.

Control strategies:

- Japanese beetle adults are attracted to plants damaged by feeding, so damage should be controlled early.
- Insecticides can be used to target adults or the grubs in the soil. Control of the grubs in turf is warranted only if numbers exceed 7 grubs/square foot in non-irrigated lawns or 15 grubs/square foot in irrigated lawns. The pH of spray water can have a significant impact on insecticide efficacy.
- Biological control options include several parasites and pathogens. These have been successfully introduced in Michigan.

Black Vine Weevil *(Otiorhynchus sulcatus)*

Regulated under: Michigan general pest laws, a **quality pest**.

Status in Michigan: established in Michigan.

The black vine weevil is believed to have been accidentally imported from Europe through the movement of ornamental plants. Its first detection in the United States occurred in New England over 100 years ago. Since then it has become a serious pest of nursery and landscape plants throughout the United States and is firmly established in Michigan. This pest is a common reason for nursery stock in Michigan to be restricted.

Damage: Larvae cause the most serious injury by feeding on the bark of roots and stems. Foliage of plants injured by the larvae may turn brown or die suddenly. Adults feed on foliage and cause notching on the margins of leaves. Common hosts of this pest

are azalea, rhododendron, euonymus, hemlock, yew, strawberry, grape, and many broad-leaved nursery plants.

Identification: The larvae and pupae are found in the soil. Adults are snout beetles, about 3/8 inch long with elbowed antennae. They are gray to brownish black in color with small pits and patches of short golden hairs. All adults are female and unable to fly. Adult weevils are active at night, but can be detected during the day by laying down boards or using pitfall traps. The larvae are small, legless, C-shaped grubs growing to about 5/8 inch long.

Black vine weevil adult and larva.

Life cycle: The black vine weevil overwinters in the soil as grubs or as adults. In early spring, the larvae mature and feed on roots. They pupate and emerge as adults from late May through June. Adults feed on foliage for 21 to 45 days prior to egg laying. Adult weevils lay eggs in the soil or leaf litter. Egg laying continues for extended periods during the summer. Each adult can lay over 200 eggs. After hatching, the larvae feed on small plant rootlets, moving to larger roots and underground stems as they grow larger. When the soil temperature drops, they move deeper in the soil to overwinter.

Control strategies:

- This pest has a high level of resistance to insecticides
- Management is usually targeted toward adults. Nursery fields should be sprayed with a recommended insecticide when the weevils first emerge followed by another spray two weeks later.
- For container production, growers have been very successful by incorporating specific insecticides into the growing medium. This can be effective for two years.
- A biological control option, nematodes that attack the grubs, has been effective in potted plants. Adequate soil moisture is essential for this option.

Cherry Fruit Fly

Regulated under: Michigan general pest laws, a quality pest.

Status in Michigan: established in Michigan.

Two species of cherry fruit flies attack stone fruits in Michigan—the cherry fruit fly *(Rhagoletis cingulata)* and the black cherry fruit fly *(Rhagoletis fausta)*. For practical purposes, the two species can be considered one because the life cycles and control measures for them are almost identical. Sweet cherry, tart cherry, black cherry, pin cherry, mahaleb cherry, and choke cherry are all hosts for cherry fruit flies.

Damage: The primary damage is caused by the maggots feeding within the fruit. Infested fruit appears normal until the maggot is nearly full-grown at which time sunken spots begin to appear. Infested fruit cannot be sold. Damage is also caused by oviposition punctures, usually found near the bottom of the fruit.

Identification: Adult flies are black with a brown head and a small cream or yellow dot on their thorax. They have clear wings with distinctive black markings and are approximately two-thirds the size of a house fly. The larvae are white, legless maggots that measure about 7 mm at maturity. The pupae are golden to dark brown, resemble a grain of wheat, and are approximately 4 mm long.

Cherry fruit fly adult and larvae.

Life cycle: Cherry fruit flies have one generation per year. They overwinter in the soil as pupae and emerge as adults in mid-June for the black cherry fruit fly and mid to late July for the cherry fruit fly. After 10 days the females begin laying eggs by inserting eggs beneath the skin of the fruit. Each female can lay 300 to 400 eggs over a three- to four-week period. After 5 to 7 days, maggots hatch and feed for two weeks in the fruit. Mature larvae drop, burrow into the ground, and pupate.

Control strategies:

- Harvest as much fruit as possible to reduce fruit flies in orchards.
- Remove alternate hosts, including abandoned orchards.
- Monitor by using yellow sticky traps set in the foliage of cherry trees in June.
- Insecticides should be aimed at killing the adults before they lay eggs. Larvae inside the fruit are protected from treatments. Insecticide treatments should begin approximately five to six days after the first catch of adult flies in sticky traps.

DISEASE PESTS

Regulated pests in Michigan also include some important diesase pests. Some are are not known to be in Michigan, but quarantines and inspections are necessary to keep these potentially very damaging diseases from becoming established. Understanding what a plant disease is, what conditions favor their establishment, and the elements in the disease cycle is the key to establishing effective control programs.

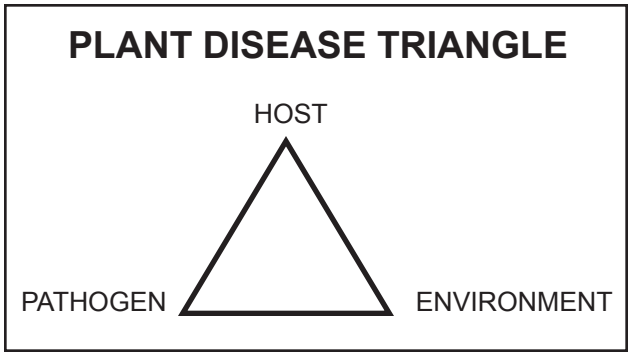
PLANT PATHOGENS

An **infectious plant disease** is caused by an agent that attacks and feeds on the host plant. The disease-causing agent is called a **pathogen**. Regulated pathogens include fungi, bacteria, viruses, and nematodes. Pathogens may be spread from diseased plants to healthy plants by wind, rain, soil, people, machinery, and insects.

PLANT DISEASE TRIANGLE

Plant diseases occur when a pathogen attacks a susceptible plant (the **host**) under environmental conditions that favor infection and growth of the pathogen. Plant diseases are the result of a complex interaction between the host, the pathogen, and the environment. This interaction is often pictured as the disease triangle. By changing any corner of the disease triangle, such as adding an unfavorable environment or using a disease-resistant variety, you can reduce disease development.

The role of the environment in this interaction is important because diseases need specific conditions to develop. Temperature and moisture are two of the most important environmental conditions that influence plant diseases.



Air and soil temperature affect the growth of the host plant or pathogen. If the host plant is stressed or grows poorly, it may be more susceptible to certain pathogens. Temperature may also change the speed of growth of a pathogen.

Pathogens and host plants are also affected by moisture. Most fungal spores need moisture to germinate. A host plant experiencing moisture stress may be more susceptible to some pathogens. Also, many pathogens are spread by wind-blown rain or require moisture on plant surfaces to infect the plant.

A successful disease management program takes into account the interactions of the environment, the disease and the host plant. Disease management emphasizes reducing pathogen survival and limiting

pathogen dispersal. For example, planting resistant varieties, improving soil drainage, and destroying or removing infected plants change one or more aspects of the disease triangle.

DISEASE CYCLE

The basic chain of events involved in disease development is called the disease cycle. The steps are:

1. **Production of inoculum. Inoculum** is a source of a pathogen that infects and causes a disease (for example, fungal spores, bacterial cells, and virus particles). Inoculum can be present in soil, seed, weeds, crop residue or other crops, or be carried by wind, rain, insects, animals, people, and machinery.

2. **Spread of inoculum.** The inoculum must disperse to the host plant. There are two types of spore movement—active and passive. **Active movement** occurs when the inoculum is carried to the host by its own action (for example, growing mycelia or swimming spores). **Passive movement** is movement of the inoculum to a new host plant by wind, water, or another organism. Most fungal and bacterial foliar pathogens disperse this way.

3. **Infection.** Infection occurs when the plant pathogen becomes established in the host. A successful plant pathogen grows, spreads within the host plant, and produces new inoculum. As the pathogen grows in the host plant, symptoms begin to appear. The time period between infection and the appearance of the first symptoms is called the **incubation period**. It can be several days to months long.

Plum Pox (Plum pox virus)

Regulated under: federal quarantine.

Status in Michigan: not known to be established in Michigan.

Plum pox, also called sharka, was first detected in Europe in the early 1900s. Since that time it has become an extremely important viral disease of stone fruits in Europe. Found in Europe, Egypt, Turkey, Syria, India, Chile, and Canada, the D strain was discovered in Pennsylvania in 1999.

Damage: Plum pox is a virus that infects a wide variety of stone fruits including peaches, apricots, plums, almonds, and cherries. Wild and cultivated *Prunus* species are the most common hosts. Plums are usually more severely infected and therefore are a good indicator species to observe for symptoms of the disease. Infected trees show a wide range of leaf, flower, and fruit symptoms depending on the cultivar, age, and nutritional status of the tree as well as environmental factors such as temperature. Leaves and fruit can show yellow rings or yellowing line patterns and blotches. Fruit can also be deformed and bumpy. Some trees show no symptoms on the leaves or fruit. Infected trees may drop their fruit prematurely. Plum pox can cause fruit to be unmarketable and can decrease the yield of infected trees.

Symptoms of plum pox virus on apricot fruit and leaves.

Description and life cycle: The virus is transmitted by several aphid species and also by infected nursery stock, propagative materials, mechanical inoculation, and possibly through seed. It is not transmitted by contact between plants or by pollen. Aphids spread plum pox within an orchard and to neighboring orchards by sucking sap from infected plants and transmitting the virus to a new plant during feeding. This non-persistent transmission means that the virus is only on the stylet, (i.e., the aphid's mouthpart) for minutes or hours. Long distance spread is usually the result of shipping infected nursery stock or propagative materials such as rootstock or scion. Four strains of PPV have been identified in Europe and Egypt.

Control strategies:

- The best control is to exclude the virus from entering an area.
- If prevention fails the next strategy is to eliminate virus-infected trees as quickly as possible to avoid furthering the spread.
- Trees infected with plum pox cannot be cured, and a single infected tree can serve as a vector host for any nearby trees.
- Field surveys, use of certified nursery materials, control of aphids, and elimination of infected trees are all control and prevention strategies.

Sudden Oak Death (*Phytophthora ramorum)*

Regulated under: federal quarantine.

Status in Michigan: not known to be established in Michigan.

Sudden oak death was first observed in coastal California in the mid 1990s. The pathogen, *Phytophthora ramorum* was identified in 2000 as the cause of the dying oak trees in California. Since that time, this disease has grown to epidemic proportions in some California counties. It has also been found in Oregon and Washington, and plant material infected with *Phytophthora ramorum* has been found in garden centers and nurseries in several states. This pathogen was also discovered in Europe in the 1990s. The country of origin is not yet known.

Damage: This pathogen causes two sets of symptoms. Tanoaks, oaks, and other members of the oak family can exhibit sudden oak death (SOD). SOD causes lethal stem cankers in the inner bark that expand and kill the tree. Symptoms of SOD include bleeding and oozing of a dark reddish brown sap on oaks, typically on the lower portions of the tree (less than 10 feet high). Bleeding may be found higher on the tree (up to 60 feet) in some cases. On some oak species, the first symptom is drooping of new growth. Death of the trees can occur very rapidly. Cankers have girdled tanoak trees within four months of infection.

The second set of symptoms is a foliar blight and shoot dieback that occurs on many host species including rhododendron, buckeye, madrone, manzanita, bigleaf maple, bay laurel, and evergreen huckleberry. The list of hosts continues to grow. These species can serve as a reservoir of inoculum, or a source of spores to infect oaks. . A listof known and suspected hosts can be found at [http://www.aphis.usda.gov/ppq/ispm/pramorum/].

Two symptoms caused by *Phytophthora ramorum*: A canker on coast live oak (top), and foliar blight on rhododendron (bottom).

Description and life cycle: The fungus *Phytophthora ramorum* produces three types of spores—zoospores, sporangia, and chlamydospores. Sporangia can infect plant tissue by direct contact or by wind dispersal. Zoospores have tails that they can use to swim through water, so irrigation or rainwater can move zoospores around. Zoospores can also form cysts and remain viable in the soil and infect new plant tissue later. Chlamydospores can lie dormant for long periods and can tolerate drought, which makes it difficult to grow plants in areas that were previously infested. Infected plants can produce spores and infect other plants within a short time of exposure to the disease.

Control strategies:

- At this time, very little can be done to treat infected plants. The best strategy is to prevent the movement of infested material.

- Active monitoring and early detection are essential to successful eradication.
- Correct identification is important. There are several other diseases and symptoms that resemble SOD.

Chrysanthemum White Rust (*Puccinia horiana)*

Regulated under: federal quarantine.

Status in Michigan: not known to be established in Michigan.

This disease has the potential to be extremely damaging to the commercial horticulture and florist industries if it becomes established in the United States. The disease is indigenous to China and Japan, but has since spread to Europe, Australia, South America, and Africa. Chrysanthemum white rust (CWR) has been accidentally introduced several times in the United States over the past several decades, but aggressive eradication programs have successfully prevented establishment.

Damage: In nurseries this can be a very serious disease and cause complete loss of greenhouse chrysanthemum crops. Several species of chrysanthemum (*Dendranthema*) have been shown to be hosts for the rust. These include florist's mum, hardy mum, and cultivated chrysanthemum. Other susceptible plants include the Nippon daisy or Nippon-chrysanthemum (*Nipponanthemum* spp.) and the high daisy or giant daisy (*Leucanthemella* spp.).

Description and life cycle: Light green to yellow spots (which may be dimpled) appear on the upper surface of infected leaves. Eventually the spots turn brown and become necrotic. Spore forming pustules appear on the lower surface of the leaves and are buff to pink color. As these pustules mature, they become white in color. These symptoms most commonly occur on younger leaves and flower bracts, but can occur on other green tissue and on petals. Symptom development is limited or absent during hot and dry weather and may be suppressed by fungicide applications.

Close-up of a chrysanthemum white rust pustule (top), and an infected plant (bottom).

The disease is moved from infected stock to healthy plants primarily by splashing water that contains spores. Free water on the leaves is necessary for spore development. Under optimal conditions, new infection can be established in as little as five hours. CWR spores can travel 1/4 mile under high humidity conditions or during a rainstorm. CWR can also be spread to uninfected plants on contaminated soil, litter, dead leaves, gardening equipment, clothes, shoes, and hands. Infectious spores can live for up to eight weeks on contaminated objects.

Control strategies:

- The spread of the disease has been checked primarily by exclusion (quarantines). When CWR has entered the United States, survey, sanitation, modified cultural practices, and fungicides have been employed to eradicate the disease.
- Since infectious spores can only live for up to eight weeks, the disease cycle can be broken by a host free period of eight weeks.
- Hot water treatments (5 minutes at 115 degrees F) may eradicate the disease.
- Management of the humidity and water can also limit disease spread.

- Fungicides like myclobutanil have been shown to be highly effective in reducing or eliminating infections of CWR.

X-Disease of Peach

Regulated under: Michigan state exterior quarantine.

Status in Michigan: established in Michigan.

X-disease is a disease of peaches and cherries in Michigan and other northern states. X-disease is commonly spread from infected chokecherry (*Prunus virginiana* L.) into Michigan peach and cherry orchards by leafhoppers. According to Michigan Regulation 612, chokecherry (*Prunus virgianiana*) is prohibited from being grown or sold within 1000 feet of peach or cherry nursery stock; or within 500 feet of peach or cherry orchards.

Damage: Trees often show no symptoms at the beginning of the growing season and then show sudden symptoms in mid-summer. New infections often appear on one to two limbs, while older infections often show symptoms on several limbs. After about two months of growth, leaves on certain limbs with develop irregular yellow to reddish purple spots. The centers of these spots drop out leaving tattered leaves. The leaves usually drop prematurely leaving tufts of leaves at the tips of infected shoots. After appearing normal at the beginning of fruit set, fruit on infected limbs with also drop prematurely.

Description and life cycle: X-disease is caused by a **phytoplasma**, an organism similar to bacteria but without cell walls that grows in the phloem of host plants. It is transmitted by several species of leafhoppers that feed on the phloem of orchard groundcover during the day and move to cherry and peach trees at night. The leafhoppers may get the phytoplasma by feeding with their piercing-sucking mouthparts on infected chokecherry, sweet cherry, or sour cherry. They can transmit the pathogen to healthy leaves while feeding two or three weeks later.

Since chokecherry serves as the reservoir for this pathogen, it is important that it is correctly identified. Chokecherry can be confused with wild black cherry (*P. serotina* Ehrh) and pin cherry (*P. pennsylvanica* L., also called fire cherry). Wild black cherry is very common in woods along orchards and can grow to heights of 80 feet or more whereas chokecherry and pin cherry rarely reach more than 30 feet tall and tend to be more bush-like in appearance. The undersides of chokecherry have smooth midveins compared with the hairy midveins of wild black cherry.

Chokecherry often serves as a reservoir for the pathogen that causes x-disease.

Control strategies:

- Eradication of chokecherry helps control this disease. Pesticides, bulldozing, deep plowing, burning or pulling out bushes are all ways of removing chokecherry. The treated area should be checked each growing season for new sprouts or seedlings.
- Management of the leafhoppers is also important. Frequent mowing, control of plant hosts at the edge of the orchard, herbicide strips under the trees and planting plants on the orchard floor that are not hosts for leafhoppers can all help discourage leafhopper activity.

White Pine Blister Rust (*Cronartium ribicola)*

Regulated under: Michigan Act 313.

Status in Michigan: established in Michigan.

White pine blister rust is a serious problem in many areas of the north central states. Because of the importance of *Ribes* spp. (currants and gooseberries) in the life cycle of this pathogen, Michigan Act 313 prohibits the sale of black currant roots, cuttings, scions, or plants. Rust-resistant currant varieties

may be sold under special permit if approved by the Michigan Department of Agriculture.

Damage: The fungus infects needles and young stems through their stomata (natural holes used for air exchange in plants). The fungus grows into the wood, causing cankers (areas of dead bark). The bark becomes discolored and turns yellowish at the canker edges. Seedlings are most likely to be killed by this disease. On older trees, infection can result in death of the tree by girdling the stem or in the killing of the top or branches which can deform and weaken the tree.

Clockwise from top left: **Orange spores on the underside of a *Ribes* leaf, spores produced in blisters on white pine, spores and pitch on a white pine canker.**

Description and life cycle: This pathogen has a very complex life cycle that involves two very different hosts and several different types of spores. Weather greatly affects the severity of this disease. Optimum conditions for this fungus are cool, wet weather with temperatures averaging below 67 degrees F from July to September. Cankers on white pine are most easily seen in the spring when orange-yellow spots appear on the bark of the cankers. In late spring and early summer, these areas will form blisters containing a sticky, yellow-orange fluid that later turns dark and hard. The pustules and blisters on the pines are part of the spore formation cycle of the rust fungus. Spores produced on the pine can only infect plants in the genus *Ribes* (gooseberries and currants). *Ribes* infected with white pine blister rust form orange and brown spores on the undersides of their leaves. The brown spores form in hairlike projections under the leaves in late summer and early fall. The spores produced on these projections will infect white pine. Only pines that are members of the genus *Pinus* that have five needles per bundle (including eastern white pine, *Pinus strobus*) serve as the pine hosts.

Control strategies:

- Eastern white pine should not be planted in areas of high disease incidence. Other pines, such as red pines, are not susceptible.
- For new white pine plantings, eradicate *Ribes* within 400 feet of the planned planting site.

Dogwood Anthracnose (*Discula destructiva)*

Regulated under: Michigan general pest laws, a quality pest.

Status in Michigan: established in Michigan.

Dogwood anthracnose was introduced into the United States in the 1970s. Since that time, it has killed and devastated native flowering dogwoods (*Cornus florida*) in the eastern and northwestern United States. This disease first entered Michigan near Kalamazoo in 1990 on imported dogwoods.

Damage: One symptom of infection is small tan leaf spots. Dead leaves first occur in the lower crown and progress up the tree. The fungus also enters terminal twigs and weakens the tree. Succulent shoots often develop at the base of a weakened tree. The pathogen forms quickly growing cankers, often appearing first on the new shoots. These cankers can spread from the shoots onto the trunk. Once cankers form on the trunk, they rapidly kill the tree by girdling it. A tree can die in two to three years. Japanese flowering dogwood, *Cornus kousa*, can act as a carrier for this disease but rarely develops severe symptoms.

Description and life cycle: Leaves develop tan spots or blotches that often expand, killing the entire leaf. The white bracts of flowers may also become spotted during a wet spring. Fruiting bodies of the fungus appear as tiny tan or brown specks on the undersides

of leaves. Infection moves from the leaves to the twigs, and cankers develop from leaf nodes causing twig dieback. Dead twigs appear tan and are often covered with black (pin point) fruiting bodies of the fungus During wet weather these produce masses of orange spores. The best conditions for this disease are high humidity, cool temperatures (60 to 70 degrees F) and shade. Spores can be washed onto new leaves by rain or sprinkler irrigation.

Clockwise from top left: **dogwood anthracnose symptoms on flower bracts, a canker on the trunk, shoot dieback, and leaf spots.**

Control strategies:

- Stressed trees are more susceptible than healthy trees. Maintain tree health with proper watering, mulching, and fertilizing.
- Plant trees in open areas with morning sun and good air circulation. Do not use overhead watering.
- Avoid planting imported dogwoods near native stands.
- Prune and destroy dead and dying twigs and branches and rake up fallen leaves to reduce the sources of inoculum (spores).

Soybean Cyst Nematode (*Heterodera glycines)*

Regulated under: other state exterior quarantines.

Status in Michigan: established in Michigan.

Host plants: Soybeans, dry beans, and other legume crops (green beans, green peas) and weeds (henbit, field pennycress, shepherd's purse). Over 1,100 species of plants are reported as potential hosts but most species are merely maintenance hosts.

First detection in Michigan: 1987.

Life cycle: The adult female soybean cyst nematode mates with a male and produces 150 to 500 eggs. Shortly after mating, she dies. But first she deposits a few eggs on the outside of her body. The other eggs remain in her dead body, which is called a **cyst**. In the cyst the eggs are protected from predators and environmental factors that would kill them. The eggs in the cyst hatch over the next eight years. Soybean cyst nematode eggs survive best under cool, moist conditions. The juveniles emerge from the eggs and immediately begin searching for food—soybean roots. Once the juveniles find a soybean root, they enter the root and begin to feed. A juvenile soybean cyst nematode molts four times before becoming an adult nematode. Under moderate soil conditions, it takes 21 to 24 days for a soybean cyst nematode to complete its life cycle.

Damage and symptoms: The most common above-ground symptoms of soybean cyst nematode damage are stunted and yellowed plants. Symptoms are usually not evenly distributed in a field. In early July, white female soybean cyst nematodes are found attached to plant roots. As the nematodes age, they become yellow. The attached females are the only visible sign of a soybean cyst nematode infestation. Soybean cyst nematode infestations can reduce soybean yields by 30 percent without plants showing symptoms. Severe infestations can reduce soybean yields as much as 80 percent.

Management options:

- The nematode can be dispersed by many different ways making prevention by quarantine ineffective. Birds may spread cysts, eggs, and larvae. Dispersion is assisted by storms (nematodes and cyst become air-borne), by surface water, and mechanically as infested soil or plants are transported.
- To prevent infestations, practice crop rotation, plant nematode-free seed, and maintain clean machinery. Weed management is also important

because many of the known hosts of this nematode are weeds.

- Nematode-resistant and -tolerant soybean varieties are available.
- Fields with low to moderate soybean cyst nematode populations can be managed by practicing a three-year crop rotation. Longer rotations may be necessary for fields with large soybean cyst nematode populations.
- Soil fumigants are available but are very expensive. Non-fumigant nematicides applied at planting may reduce soybean cyst nematode populations. In many situations, they, too, are very costly.

CHAPTER 5

REVIEW QUESTIONS

Chapter 5: Pests of Concern

Write the answers to the following questions and then check your answers with those in the back of the manual.

1. Which is the correct life cycle for insects that undergo complete metamorphosis?
   A. Egg, nymph, adult
   B. Egg, nymph, larva, adult
   C. Egg, larva, pupa, adult
   D. Egg, pupa, larva, adult

2. Why is it important to manage insects that undergo complete metamorphosis according to their particular life stage?

Match the following regulatory pests of trees with the appropriate description.

A. Asian longhorned beetle
B. Hemlock woolly adelgid
C. Emerald ash borer
D. Gypsy moth
E. Pine shoot beetle

_____ 3. Regulated under a state exterior quarantine.

_____ 4. Not known to be established in Michigan; a serious threat to hardwood trees.

_____ 5. Adults are a shiny black beetle with white spots on the upper and lower body; it has very long antenna with alternating black and white bands.

_____ 6. Adults are a dark metallic green wood-boring beetle.

_____ 7. Has more than 250 known host plants but prefers oak or aspen.

_____ 8. Immature nymphs and adults damage trees by sucking sap from the twigs and by injecting a toxic saliva while feeding.

_____ 9. Adults are reddish-brown to black cylindrical beetles, 3 to 5 mm long.

_____ 10. An early sign of infestation is white, cottony egg sacs on the undersides of twigs.

_____ 11. The larvae are hairy caterpillars with five pairs of blue spots and 6 pairs of red spots along their backs.

_____ 12. A state interior quarantine is in effect for many counties in southern Michigan.

_____ 13. *Bacillis thuringensis* (B.t.) effective at controlling larvae.

_____ 14. The upper third of a tree will die back first, followed by the rest of the tree's decline within the next year.

_____ 15. Trap logs are used to capture adults in search of brood material.

Match the following regulatory insect pests with the appropriate description.

A. Japanese beetle
B. Black vine weevil
C. Cherry fruit fly

_____ 16. Two species are pests of stone fruits in Michigan.

_____ 17. Regulated under other state exterior quarantines.

_____ 18. Adults skeletonize leaves leaving only veins; grubs feed on plant roots.

_____ 19. Larvae cause the most serious injury by feeding on the bark of roots and stems.

_____ 20. Cause damage by larvae feeding within the fruit.

_____ 21. Adults are snout beetles, about 3/8 inch long with elbowed antennae.

_____ 22. Control of grubs is warranted only in numbers exceed 7 grubs/square feet in non-irrigated lawns, or 15 grubs/square foot in irrigated lawns.

_____ 23. Insecticides should be aimed at killing the adults before they lay eggs; treatments should begin approximately five to six days after the first catch of adults.

_____ 24. Growers have been successful at controlling this pest by incorporating insecticides into the growing medium.

25. What are the three parts of the disease triangle? How can the triangle be changed to prevent or reduce the incidence of disease?

26. What are the basic steps in the disease cycle?

Match the following regulatory tree diseases with the appropriate description.

A. Sudden oak death
B. White pine blister rust
C. Dogwood anthracnose

_____ 27. One symptom of infection is small, tan leaf spots; the fungus also enters terminal twigs and weakens the tree; cankers form on shoots.

_____ 28. Cause lethal stem cankers in the inner bark; many host species symptoms include a foliar blight and shoot dieback.

_____ 29. Not known to be established in Michigan.

_____ 30. Introduced into the United States in the 1970s.

_____ 31. Currants and gooseberries (*Ribes* spp.) are important in the life cycle of this pathogen.

_____ 32. In the spring, orange-yellow spots appear on the bark of stem cankers.

Match the following regulatory plant diseases with the appropriate description.

A. Plum pox
B. Chrysanthemum white rust
C. X-disease of peach
D. Soybean cyst nematode

_____ 33. In nurseries this can be a very serious disease and cause complete loss of the crop.

_____ 34. Light green to yellow spots (which may be dimpled) appear on the upper surfaces of infected leaves.

_____ 35. The disease is a phytoplasma spread by leafhoppers.

_____ 36. Above ground symptoms include stunted and yellowed plants; the symptoms are not evenly distributed in a field.

_____ 37. Aphids transmit this virus during feeding.

_____ 38. Chokecherry serves as the reservoir for this pathogen.

_____ 39. Dispersed by many different ways, making prevention by quarantine ineffective.

_____ 40. Leaves and fruit can show yellow rings or yellowing line patterns and blotches.

Appendix A

Answers to Review Questions

Chapter 1. Introduction to Regulatory Pest Management

(1) To prevent the introduction and/or spread of pests through the application of various pest management techniques.

(2) D.

(3) Any organism that is introduced to a new, non-native location, and is likely to cause economic or environmental harm or harm to human health.

(4) D.

(5) The introduction must be into an area with a suitable environment, suitable host, and include viable pests in sufficient numbers to allow for reproduction and spread.

(6) Knowledge of the pest's life cycle helps identify the critical life stages at which control measures can be developed that will have a significant impact on reducing the population.

Chapter 2. Elements of a Regulatory Program

(1) The goal is to prevent the introduction, colonization, and establishment of pests that would cause significant agricultural, environmental, and/or societal harm in an area where the pest does not already occur.

(2) You must determine if the costs associated with preventing the probable level of harm are worth the benefits.

(3) C. (4) B. (5) A. (6) A. (7) B. (8) C.

(9) The use of pesticides.
The release of parasites or predators.
The release of sterile mates.
The removal of the host.
The use of varieties that are resistant to the pest.

(10) The pest must be identified correctly to know which strategies will work best to prevent or control the pest; keeping accurate records is essential for making valid and meaningful pest pathway studies, risk analyses, and quarantine evaluations.

(11) The public must know what quarantine restrictions exist and why they exist in order to be motivated to comply with them and to support funding for them.

Chapter 3. Laws and Regulations

(1) Plants, plant products, biological control organisms, noxious weeds, articles being imported, entered, exported, or moved interstate must:

- Be accompanied by a permit issued prior to the importation, entry, exportation, or movement in interstate commerce.
- Be accompanied by a certificate of inspection by appropriate officials of the country or state from which the plant, plant product, biological control organism, noxious weed, or article is to be moved.
- Be subject to remedial measures to prevent the spread of plant pests or noxious weed.
- Be grown or handled under post-entry quarantine conditions to determine whether the plant or biological control organism may be infested with plant pests or may be a plant pest or noxious weed.

(2) True.

(3) False. Michigan has authority to enact state quarantines through Public Act 189, the Insect Pest and Plant Disease Act.

(4) Exterior quarantines are designed to restrict movement of pests into Michigan; interior quarantines regulate the movement of pests within the state.

(5) The state or federal phytosanitary certificate may be required when shipping agricultural products from the United States to a foreign country or from Michigan to another state, or when attempting to bring certain agricultural products into the United States or into Michigan from other areas.

(6) State or federal inspectors may be required to verify that certain pest control treatments have occurred before these shipping documents can be issued.

(7) To help reduce the incidence of diseases that are difficult to detect, such as plant viruses, when importing plants from a foreign country to the U.S.

(8) A.

(9) False. The MDA conducts surveys for pests not known to occur in the state when there is a serious threat or potential for infestation.

(10) Supplemental labeling is additional information that is considered part of the pesticide label. It may be supplied at the time of purchase or requested from the pesticide dealer. Supplemental labels may include Special Local Needs labels (24c), Emergency Exemption labels (Section 18) as well as additional use information issued by the pesticide manufacturer. If an applicator applies a pesticide according to a supplemental label, a copy of the supplemental label must be in the applicator's possession at the time of application.

(11) APHIS manuals, 24 (c) registrations, or Section 18 labels.

Chapter 4. Using Pesticides in Regulatory Programs

(1) C.

(2) Biological controls, elimination of the pest's food source or habitat, creation of a buffer zone.

(3) A.

(4) Point-source-pollution comes from a specific source or location; non-point source comes from a generalized area or weather event.

(5) Any five of the following:

- Use integrated pest management.
- Consider the geology of your area when locating wells, mix/load sites or equipment washing sites.
- Be aware of the water table depth and how fast water moves through the geological layers between the soil surface and the groundwater.
- Select pesticides carefully.
- Be aware of pesticides that are very water-soluble.
- Read pesticide labels carefully,
- Follow pesticide label directions.
- Calibrate accurately.
- Measure accurately.
- Avoid back-siphoning.
- Consider weather conditions.
- Mix on an impervious pad.
- Dispose of wastes and containers properly.
- Store pesticides safely and away from water sources.

(6) B. (7) D. (8) A.

(9) Cross-resistance occurs when pests that are resistant to one pesticide show resistance to chemically related pesticides.

(10) Use integrated pest management.

Use pesticides from different chemical families with different modes of action.

Use pesticides only when needed, and use only as much as necessary to effectively maintain control.

(11) A. True.

(12) A map of all areas where pesticide applications occur.

A list of pesticide-sensitive sites located near an application area.

Pesticide label and mandated restrictions that relate to setback provisions from sensitive areas.

Information for persons in sensitive areas regarding the type of pesticide used, the method of application, and the applicator's plan to minimize pesticide drift.

(13) B.

(14) The name, address, and phone number of the application firm or individual.

The brand name and active ingredient(s) of the pesticide(s) used.

The method of application.

The scheduled date(s) of application.

The name, address, and phone number of a contact person who is responsible for supplying updated information concerning the application for those people who request it.

Any re-entry restrictions.

(15) C.

Chapter 5. Pests of Concern

(1) C.

(2) Because certain stages of particular insect's life cycle are more susceptible to control measures.

(3) B. (4) A. (5) A. (6) C. (7) D. (8) B.

(9) E. (10) B. (11) D. (12) C. (13) D. (14) C.

(15) E. (16) C. (17) A. (18) A. (19) B. (20) C.

(21) B. (22) A. (23) C. (24) B.

(25) Host, pathogen, and environment. By changing any corner of the disease triangle, such as adding an unfavorable environment or using a disease-resistant variety, you can reduce disease development.

(26) 1. Production of inoculum.
2. Spread of inoculum.
3. Infection.

(27) C. (28) A. (29) A. (30) C. (31) B. (32) B.

(33) B. (34) B. (35) C. (36) D. (37) A. (38) C.

(39) D. (40) A.

Appendix B

Conversion Tables

Area

144 square inches . . . . . 1 square foot
9 square feet . . . . . 1 square yard
43,560 square feet. . . . . 1 acre
4,840 square yards . . . . . 1 acre
160 square rods . . . . . 1 acre
640 acres. . . . . 1 square mile
2.5 acres . . . . . 1 hectare

Length

1 inch . . . . . 2.54 centimeters . . . . . 5.5 millimeters
1 foot . . . . . 12 inches
1 yard . . . . . 3 feet
1 rod. . . . . 5.5 yards . . . . . 16.5 feet
1 mile. . . . . 320 rods. . . . . .1,760 yards . . . . . 5,280 feet
1 meter. . . . . .39.4 inches. . . . . 1.09 yards
1 kilometer . . . . . 1,000 meters . . . . . 0.62 mile

Volume

1 tablespoon (tbs or T) . . . . . 3 teaspoons (tsp or t)
1 fluid ounce. . . . . 2 tablespoons
8 fluid ounces . . . . . 16 tablespoons . . . . . 1 cup
16 fluid ounces . . . . . 2 cups. . . . . 1 pint
32 fluid ounces . . . . . 4 cups . . . . . 1 quart
128 fluid ounces . . . . . 4 quarts . . . . . 1 gallon
1 liter . . . . . 33.9 ounces . . . . . 1.06 quarts

Weight

1 ounce . . . . . 28.3 grams
1 pound. . . . . 16 ounces. . . . . 453.6 grams
2.2 pounds . . . . . 1 kilogram . . . . . 1,000 grams
1 ton . . . . . 2,000 pounds . . . . . 907 kilograms
1 metric ton . . . . . 1,000 kilograms . . . . . 2,205 pounds

Appendix C

Selected Bibliography

Internet Reference Sites

PestTracker (Joint site by NAPIS, USDA APHIS, USDA PPQ and CAPS):
[http://ceris.purdue.edu/napis/index.html]

Invasivespeciesinfo.gov:
[http://www.invasivespeciesinfo.gov]

The National Plant Board:
[http://www.aphis.usda.gov/npb]

Invasive Species Initiative:
[http://www.invasivespecies.msu.edu]

Invasive Species Images:
[http://www.invasive.org]

Michigan Department of Agriculture:
[http://www.michigan.gov/mda]

Michigan State University Integrated Pest Management Program:
[http://www.msue.msu.edu/ipm]

Michigan State University Pesticide Education Program: **[http://www.pested.msu.edu/]**

National Pesticide Information Center:
[http://ace.orst.edu/info/npic/tech.htm]

The Extension Toxicology Network:
[http://ace.orst.edu/info/extoxnet/]

Environmental Protection Agency (EPA):
[http://www.epa.gov/]

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Appendix D

Glossary of Terms for Regulatory Pest Management

ABDOMINAL PROLEGS — The false, peglike legs on the abdomen of a caterpillar.

ABSORPTION — The movement of a chemical into plants, animals (including humans) and/or microorganisms.

ACARICIDE — A pesticide used to control mites and ticks. Amiticide is an acaricide.

ACTION THRESHOLD — See ***economic threshold***

ACTIVE INGREDIENT — The chemical or chemicals in a pesticide responsible for killing, poisoning, or repelling the pest. Listed separately in the ingredient statement.

ACUTE TOXICITY — The capacity of a pesticide to cause injury within 24 hours following exposure. LD_{50} and LC_{50} are common indicators of the degree of acute toxicity. (See also ***chronic toxicity***.)

ADJUVANT — A substance added to a pesticide to improve its effectiveness or safety. Same as additive. Examples: penetrants, spreader-stickers and wetting agents.

ADSORPTION — The process by which chemicals are held or bound to a surface by physical or chemical attraction. Clay and high organic soils tend to adsorb pesticides.

AEROSOL — A material stored in a container under pressure. Fine droplets are produced when the material dissolved in a liquid carrier is released into the air from the pressurized container.

AGGREGATION PHEROMONE — See ***pheromone***.

ALLELOPATHY — When one plant species releases toxic chemicals that eliminate a competing species.

ANAL PROLEGS — The false, peglike legs near the anus of a caterpillar.

ANNUAL — A plant that completes its life cycle in one year.

ANTIBIOSIS — A relationship between two or more organisms that negatively affects one of the organisms involved (example: plant characteristics that affect insect behavior).

ANTIDOTE — A treatment used to counteract the effects of pesticide poisoning or some other poison in the body.

ANTI-SIPHONING DEVICE — A device attached to the filling hose that prevents backflow or back-siphoning from a spray tank into a water source.

ARACHNID — A wingless arthropod with two body regions and four pairs of jointed legs. Spiders, ticks and mites are in the class Arachnida.

ARTHROPOD — An invertebrate animal characterized by a jointed body and limbs and usually a hard body covering that is molted at intervals. For example, insects, mites and crayfish are in the phylum Arthropoda.

ARTIFICIAL SPREAD— The movement of pests by people via aircraft, buses, ships, trains, trucks and automobiles.

ATTRACTANT — A substance or device that will lure pests to a trap or poison bait.

AUGMENTATION — A periodic release of natural enemies to increase the present population; a method of biological control.

AVICIDE — A pesticide used to kill or repel birds. Birds are in the class Aves.

BACK-SIPHONING — The movement of a liquid pesticide mixture back through the filling hose and into the water source.

BACTERICIDE — Chemical used to control bacteria.

BACTERIUM (plural BACTERIA) — Microscopic onecelled organisms, some of which are capable of producing diseases in plants and animals. Others are beneficial.

BAIT — A food or other substance used to attract a pest to a pesticide or to a trap.

BAND APPLICATION — The application of a pesticide in a strip or band of a certain width.

BARRIER APPLICATION — Application of a pesticide in a strip alongside or around a structure, a portion of a structure or any object.

BENEFICIAL INSECT — An insect that is useful or helpful to humans; usually insect parasites, predators, pollinators, etc.

BIENNIAL — A plant that requires two growing seasons to complete its life cycle.

BIOLOGICAL CONTROL — Control of pests using predators, parasites and disease-causing organisms. May be naturally occurring or introduced.

BIOMAGNIFICATION — The process whereby one organism accumulates chemical residues in higher concentrations from organisms it consumes.

BOTANICAL PESTICIDE — A pesticide produced from chemicals found in plants. Examples are nicotine, pyrethrins and strychnine.

BRAND NAME — The name or designation of a specific pesticide product or device made by a manufacturer or formulator; a marketing name.

BROADCAST APPLICATION — A uniform pesticide application to a field or site.

CALIBRATE, CALIBRATION OF EQUIPMENT OR APPLICATION METHOD — The measurement of dispersal or output and adjustments made to control the rate of dispersal of pesticides.

CANKER — A diseased or necrotic area on a plant part, especially on a trunk, branch, or twig of a woody plant, usually caused by fungi or bacteria.

CARBAMATES (N-methyl carbamates) — A group of pesticides containing nitrogen, formulated as insecticides, fungicides and herbicides. The N-methyl carbamates are insecticides and inhibit ***cholinesterase*** in animals.

CARCINOGENIC — The ability of a substance or agent to induce malignant tumors (cancer).

CARRIER — An inert liquid, solid or gas added to an active ingredient to make a pesticide dispense effectively. A carrier is also the material, usually water or oil, used to dilute the formulated product for application.

CARRYOVER (HERBICIDE) — When a herbicide is not broken down during the season of application and persists in quantities large enough to injure succeeding crops.

CERTIFIED APPLICATORS — Individuals who are certified to use or supervise the use of any restricted-use pesticide covered by their certification.

CHEMICAL CONTROL — Pesticide application to kill pests.

CHEMICAL NAME — The scientific name of the active ingredient(s) found in the formulated product. This complex name is derived from the chemical structure of the active ingredient.

CHEMTREC — The Chemical Transportation Emergency Center has a toll-free number (800-424-9300) that provides 24-hour information for chemical emergencies such as a spill, leak, fire or accident.

CHLAMYDOSPORES — A thick-walled fungal spore that often serves as a "resting" spore.

CHLORINATED HYDROCARBON — A pesticide containing chlorine, carbon and hydrogen. Many are persistent in the environment. Examples: chlordane, DDT, methoxychlor. Few are used in structural pest management operations today.

CHLOROPHYLL — The green pigment in plant cells that enables the plant to convert sunlight into food.

CHOLINESTERASE, ACETYLCHOLINESTERASE —An enzyme in animals that helps regulate nerve impulses. This enzyme is depressed by N-methyl carbamate and organophosphate pesticides.

CHRONIC TOXICITY — The ability of a material to cause injury or illness (beyond 24 hours following exposure) from repeated, prolonged exposure to small amounts. (See also acute toxicity.)

CLASSES — See ***taxonomy***.

COMMERCIAL APPLICATOR — A certified applicator who uses or supervises the use of any pesticide classified for restricted use for any purpose or on any property other than that producing an agricultural commodity.

COMMON NAME — A name given to a pesticide's active ingredient by a recognized committee on pesticide nomenclature. Many pesticides are known by a number of trade or brand names, but each active ingredient has only one recognized common name.

COMMUNITY — The various populations of animal species (or plants) that exist together in an ecosystem. (See also ***population*** and ***ecosystem***.)

CONCENTRATION — Refers to the amount of active ingredient in a given volume or weight of formulated product.

CONTACT PESTICIDE — A compound that kills or injures insects when it contacts them. It does not have to be ingested. Often used in reference to a spray applied directly on a pest.

CONTAMINATION — The presence of an unwanted substance (sometimes pesticides) in or on plants, animals, soil, water, air or structures.

COTYLEDONS — The first leaf or pair of leaves of a seedling.

CROSS-RESISTANCE — When a pest develops resistance to one type of pesticide and all other pesticides with a similar mode of action.

CULTIVAR — A plant variety that was created or maintained through cultivation (cultivated variety).

CULTURAL CONTROL — A pest control method that includes changing human habits — e.g., sanitation, work practices, cleaning and garbage pickup schedules, planting and harvest times, etc.

CURATIVE — The application of a control tactic after the pest has arrived.

CYST (NEMATODES) — The body of the dead adult female nematode of the genus *Heterodera* or *Globodera*, which may contain eggs.

DAMPING-OFF — A disease that destroys seedlings near the soil line, resulting in the seedlings falling over on the soil.

DECONTAMINATE — To remove or break down a pesticidal chemical from a surface or substance.

DEFOLIATION — The removal of leaves, often by insects or disease.

DEGRADATION — The process by which a chemical compound or pesticide is reduced to simpler compounds by the action of microorganisms, water, air, sunlight or other agents. Degradation products are usually, but not always, less toxic than the original compound.

DEPOSIT — The amount of pesticide on treated surfaces after application.

DERMAL TOXICITY — The ability of a pesticide to cause acute illness or injury to a human or animal when absorbed through the skin. (See ***exposure route***.)

DESICCANT — A type of pesticide that draws moisture or fluids from a pest, causing it to die. Certain desiccant dusts destroy the waxy outer coating that holds moisture within an insect's body.

DETOXIFY — To render a pesticide's active ingredient or other poisonous chemical harmless.

DIAGNOSIS — The positive identification of a problem and its cause.

DILUENT — Any liquid, gas or solid material used to dilute or weaken a concentrated pesticide.

DISEASE — A disturbance of normal plant function; caused by bacteria, fungi, viruses or environmental conditions.

DISEASE CYCLE — The basic chain of events involved in disease development.

DISINFECTANT — A chemical or other agent that kills or inactivates disease-producing microorganisms; chemicals used to clean or surface-sterilize inanimate objects.

DOSE, DOSAGE — Quantity, amount or rate of pesticide applied to a given area or target.

DRIFT — The airborne movement of a pesticide spray or dust beyond the intended target area.

DRIFT MANAGEMENT PLAN — A written plan required of commercial and private applicators by Michigan Regulation 637 whenever there is a chance of a spray application drifting from the target onto nontarget and off-site sensitive areas.

DUST — A finely ground, dry pesticide formulation containing a small amount of active ingredient and a large amount of inert carrier or diluent such as clay or talc.

ECONOMIC DAMAGE — The amount of injury that will justify the cost of applied control measures.

ECONOMIC INJURY LEVEL (EIL) — The smallest pest population that will cause economic loss to the crop.

ECONOMIC THRESHOLD (ET, ACTION THRESHOLD) — The pest density at which a control tactic should be taken to prevent the pest population from increasing to the economic injury level.

ECOSYSTEM — The pest management unit. It includes a community (of ***populations***) with the necessary physical and biotic (food, hosts) supporting factors that allow an infestation of pests to persist.

EMULSIFIABLE CONCENTRATE — A pesticide formulation produced by mixing or suspending the active ingredient (the concentrate) and an emulsifying agent in a suitable carrier. When these are added to water, a milky emulsion is formed.

EMULSIFYING AGENT (EMULSIFIER) — A chemical that aids in the suspension of one liquid in another. Normally the two would not mix together.

EMULSION — A mixture of two liquids that are not soluble in each other. One is suspended as very small droplets in the other with the aid of an emulsifying agent.

ENCAPSULATED FORMULATION — A pesticide formulation with the active ingredient enclosed in capsules of polyvinyl or other materials; principally used for slow release.

ENDANGERED SPECIES — A plant or animal species whose population is reduced to the extent that it is near extinction and a federal agency has designated it as being in danger of becoming extinct.

ENTRY INTERVAL — See ***reentry interval***.

ENVIRONMENT — All of our physical, chemical and biological surroundings, such as climate, soil, water and air, and all species of plants, animals and microorganisms.

ENVIRONMENTAL PROTECTION AGENCY (EPA) — The federal agency responsible for ensuring the protection of humans and the environment from potentially adverse effects of pesticides.

EPA ESTABLISHMENT NUMBER — A number assigned to each pesticide production plant by the EPA. The number indicates the plant at which the pesticide product was produced and must appear on all labels of that product.

EPA REGISTRATION NUMBER — An identification number assigned to a pesticide product when the product is registered by the EPA for use. The number must appear on all labels for a particular product.

ERADICATION — The complete elimination of a (pest) population from a designated area.

EXOSKELETON — The external hardened covering or skeleton of an insect to which muscles are attached internally; it is periodically shed.

EXOTIC PEST— Any organism that is introduced to a new, non-native location, and is likely to cause economic or environmental harm or harm to human health.

EXTERIOR QUARANTINE— A quarantine imposed by a state government to prevent entry and establishment of pests into their state.

EXPOSURE ROUTE OR COMMON EXPOSURE ROUTE — The manner (dermal, oral or inhalation respiratory) by which a pesticide may enter an organism.

FAMILY — See ***taxonomy***.

FEDERAL QUARANTINE — A quarantine imposed by the federal government.

FIFRA — The Federal Insecticide, Fungicide and Rodenticide Act; a federal law and its amendments that control pesticide registration and use.

FLOWABLE — A pesticide formulation in which a very finely ground solid particle is suspended (not dissolved) in a liquid carrier.

FORMULATION — The pesticide product as purchased, containing a mixture of one or more active ingredients, carriers (inert ingredients) and other additives that make it easy to store, dilute and apply.

FRASS — The excrement produced by insects.

FRUITING BODY — The part of a fungus that contains spores.

FUMIGANT — A pesticide formulation that volatilizes, forming a toxic vapor or gas that kills in the gaseous state. Usually, it penetrates voids to kill pests.

FUNGICIDE — A chemical used to control fungi.

FUNGUS (plural FUNGI) — A group of small, often microscopic, organisms in the plant kingdom that cause rot, mold and disease. Fungi need moisture or a damp environment (wood rots require at least 19 percent moisture). Fungi are extremely important in the diet of many insects.

GALLERIES — Tunnels created by insect feeding or excavating, generally found in wood.

GENERAL-USE (UNCLASSIFIED) PESTICIDE — A pesticide that can be purchased and used by the general public. (See also ***restricted-use pesticide***.)

but remains immature.

GENUS — See ***taxonomy***.

GEOGRAPHIC INFORMATION SYSTEM (GIS) — An organized collection of computer hardware, software, geographic data and personnel designed to capture, manipulate, analyze and display geographically referenced data.

GLOBAL POSITIONING SYSTEM (GPS) — A portable, satellite-based system that will establish the real-world location (position) of the GPS receiver.

GRANULE — A dry pesticide formulation. The active ingredient is either mixed with or coated onto an inert carrier to form a small, ready-to-use, low-concentrate particle that normally does not present a drift hazard. Pellets differ from granules only in their precise uniformity, larger size and shape.

GROUNDWATER — Water sources located beneath the soil surface from which springwater, well water, etc., are obtained. (See also ***surface water***.)

HAZARD — See ***risk***.

HERBICIDE — A pesticide used to kill plants or inhibit plant growth.

HOPPERBURN — A V-shaped yellow marking resulting from feeding of leafhoppers.

HOST — Any animal or plant on or in which another lives for nourishment, development or protection.

HOST RESISTANCE — The defense mechanism of an animal or plant against a pest; sometimes host plant resistance. (See ***resistance***.)

HYPHA (plural HYPHAE) — A single, delicate threadlike structure of fungus.

IGR, INSECT GROWTH REGULATOR, JUVENOID — A pesticide constructed to mimic insect hormones that control molting and the development of some insect systems affecting the change from immature to adult. (See ***juvenile hormone***.)

INCUBATION PERIOD — The time between first exposure to a pathogen and the appearance of the first symptoms.

INERT INGREDIENT — In a pesticide formulation, an inactive material without pesticidal activity.

INFECTION — The establishment of a pathogen with a host.

INFECTIOUS DISEASE — Disease caused by pathogens such as bacteria, viruses and fungi; can be spread from plant to plant.

INGREDIENT STATEMENT — The portion of the label on a pesticide container that gives the name and amount of each active ingredient and the total amount of inert ingredients in the formulation.

INHALATION — Taking a substance in through the lungs; breathing in. (See ***exposure route***.)

INOCULUM — A pathogen source that can infect and cause disease.

INSECT GROWTH REGULATOR — See ***IGR***.

INSECTICIDE — A pesticide used to manage or prevent damage caused by insects. Sometimes generalized to be synonymous with pesticide.

INSECTS, INSECTA — A class in the phylum Arthropoda characterized by a body composed of three segments (head, ***thorax*** and abdomen) and three pairs of legs.

INTEGRATED PEST MANAGEMENT — See ***IPM***.

IPM — Integrated pest management. A planned pest control program in which various methods are integrated and used to keep pests from causing economic, health-related or aesthetic injury. IPM includes reducing pests to a tolerable level. Pesticide application is not the primary control method but is an element of IPM — as are cultural, mechanical and biological methods. IPM programs emphasize communication, monitoring, inspection and evaluation (keeping and using records).

INTERIOR QUARANTINE — A quarantine imposed by a state to restrict movement of pests within the state, usually from counties known to have the pest.

INVASIVE SPECIES — A species that is non-native in that ecosystem and whose introduction causes or is likely to cause economic or environmental harm or harm to human health.

JUVENILE — The immature or larval stage of nematodes; commonly referred to as J1, J2, J3 and J4.

JUVENILE HORMONE — A hormone produced by an insect that inhibits change or molting. As long as juvenile hormone is present, the insect does not develop into an adult

LABEL — All printed material attached to or on a pesticide container.

LABELING — The pesticide product label and other accompanying materials that contain directions that pesticide users are legally required to follow.

LARVA (plural LARVAE) — An early developmental stage of insects with complete metamorphosis. Insects hatch out of eggs as larvae before becoming ***pupae*** (resting stage) and then adults.

LC50 — Lethal concentration. The concentration of a pesticide, usually in air or water, that kills 50 percent of a test population of animals. LC_{50} is usually expressed in parts per million

(ppm). The lower the LC_{50} value, the more acutely toxic the chemical.

LD50 — Lethal dose. The dose or amount of a pesticide that can kill 50 percent of the test animals when eaten or absorbed through the skin. LD_{50} is expressed in milligrams of chemical per kilogram of body weight of the test animal (mg/kg). The lower the LD_{50}, the more acutely toxic the pesticide.

LEACHING — The movement of a substance with water downward through soil.

LIFE STAGE — In an insect life cycle an egg, larva, pupa, nymph or adult.

MESOTHORAX — The second segment of an insect's ***thorax***. One pair of legs and usually one pair of wings are attached.

METABOLISM — A biochemical process that breaks a pesticide into other, often less toxic, compounds

METAMORPHOSIS — A change in the shape, or form, of an animal. Usually used when referring to insect development.

METATHORAX — The third segment of an insect's ***thorax***. One pair of legs and often one pair of wings are attached.

MICROBIAL DEGRADATION — Breakdown of a chemical by microorganisms.

MICROBIAL PESTICIDE — Bacteria, viruses, fungi and other microorganisms used to control pests. Also called biorationals.

MICROORGANISM — An organism so small it can be seen only with the aid of a microscope.

MITICIDE — A pesticide used to control mites. (See ***acaricide***.)

MODE OF ACTION — The way in which a pesticide exerts a toxic effect on the target plant or animal.

MOLLUSCICIDE — A chemical used to control snails and slugs.

MOLT — Periodic shedding of the outer layer (e.g., an insect's ***exoskeleton*** is shed periodically).

MONITORING — On-going surveillance. Monitoring includes inspection and record keeping. Monitoring records allows technicians to evaluate pest population suppression, identify infested or non-infested sites, and manage the progress of the management or control program.

MYCELIUM — A mass of hyphae; has a fuzzy appearance.

NECROSIS — Death of plant or animal tissues that results in the formation of discolored, sunken or necrotic (dead) areas.

NATURAL SPREAD — The movement that the pest is capable of without the assistance of people. This includes the movement by wind, water, birds and other wildlife.

NEMATICIDE — A chemical used to control nematodes.

NEMATODE — A small, slender, colorless roundworm; nematodes live in soil and water or as parasites of plants or animals.

NON-INFECTIOUS DISEASE — Disease caused by non-living agents such as drought, soil compaction, temperature or moisture extremes, nutrient deficiency, etc.; cannot reproduce and spread.

NON-POINT SOURCE POLLUTION — Pollution from a generalized area or weather event.

NON-RESIDUAL PESTICIDE — Pesticides applied to obtain effects only during the time of treatment.

NON-TARGET ORGANISM — Any plant or animal other than the intended target(s) of a pesticide application.

NOZZLE FLOW RATE — The amount of material that passes through the nozzle for a specific amount of time; dependent on pressure and tip size.

NYMPH — In insects with gradual metamorphosis, the developmental stage that hatches from the egg. Nymphs become adults.

ORAL TOXICITY — The ability of a pesticide to cause injury or acute illness when taken by mouth. One of the common exposure routes.

ORDER — See ***taxonomy***.

ORGANOPHOSPHATES — A large group of pesticides that contain the element phosphorus and inhibit ***cholinesterase*** in animals.

PARASITE — A plant, animal or microorganism living in, on or with another living organism for the purpose of obtaining all or part of its food.

PARASITOID — An organism that lives during its development in or on the body of a single host organism, eventually killing it.

PATHOGEN — A disease-causing organism.

PERENNIAL — A plant that lives for more than two years.

PERSONAL PROTECTIVE EQUIPMENT (PPE) — Devices and clothing intended to protect a person from exposure to pesticides. Includes such items as longsleeved shirts, long trousers, coveralls, suitable hats, gloves, shoes, respirators and other safety items as needed.

PEST — An undesirable organism (plant, animal, bacterium, etc.); any organism that competes with people for food, feed or fiber, causes structural damage, is a public health concern, reduces aesthetic qualities, or impedes industrial or recreational activities.

PESTICIDE — A chemical or other agent used to kill, repel, or otherwise control pests or protect from a pest.

PETIOLE — The stalk of a leaf.

pH — A measure of the acidity/alkalinity of a liquid — below pH 7 is acid; above pH 7 (up to 14) is basic or alkaline.

PHEROMONE — A substance emitted by an animal to influence the behavior of other animals of the same species. Examples are sex pheromones (to attract mates) and aggregation pheromones (to keep members of the same species together in a group). Some pheromones are synthetically produced for use in insect traps.

PHOTODEGRADATION — Breakdown of chemicals by the action of light.

PHYSICAL CONTROL — Habitat alteration or changing the infested physical structure — e.g., caulking holes, sealing cracks, tightening around doors and windows, moisture reduction, ventilation, etc.

PHYTOPLASMA — An organism similar to bacteria vut without cell walls that grows in the phloem of host plants.

PHYTOSANITARY CERTIFICATE — A document prepared by a duly authorized federal or state regulatory official that verifies compliance with phytosanitary (quarantine) requirements.

PHYTOTOXICITY — Plant injury caused by a chemical or other agent.

PITCH — A resin from the sap of trees, especially conifers such as pine.

POINT OF RUNOFF — The point at which a spray starts to run or drip from the surface to which it is applied.

POINT SOURCE POLLUTION — Pollution from a specific source.

POISON CONTROL CENTER — A local agency, generally a hospital, that has current information on the proper first aid techniques and antidotes for poisoning emergencies. Centers are listed in telephone directories.

POPULATION — Individuals of the same species. The populations in an area make up a community. (See ***ecosystem***.)

POSTEMERGENT HERBICIDE — Herbicide applied after weeds have emerged to kill them by contacting the foliage.

PREEMERGENT HERBICIDE — Herbicide applied before emergence of weeds to kill them as they develop (sprout).

PRECIPITATE — A solid substance that forms in a liquid and settles to the bottom of a container; a material that no longer remains in suspension.

PREDATOR — An animal that attacks, kills and feeds on other animals. Examples of predaceous animals are

hawks, owls, snakes, many insects, etc.

PREHARVEST INTERVAL — The minimum amount of time (in days) between the last application and harvest.

PRONOTUM — The area just behind an insect's head (i.e., the upper plate of the ***prothorax***).

PROPELLANT — The inert ingredient in pressurized products that forces the active ingredient from the container.

PROTECTANT — A chemical applied to a plant or animal to prevent a pest problem.

PROTHORAX — The first segment of an insect's ***thorax***. One pair of legs is attached.

PUPA (plural PUPAE) — In insects with complete metamorphosis, the developmental (resting) stage during which major changes from the larval to the adult form occur.

PUSTULE — A blister-like bump that usually contains fungal spores.

QUALITY PEST — Regulated pests that are not quarantine pests but are regulated under the authority of state law that states that plants being shipped need to be "apparently free of pests."

QUARANTINE — A legal instrument imposed or enacted by a governmental agency as a means of mitigating pest risk. A quarantine enables enforcement of prohibitions, restrictions, treatment and certification requirements and other measures necessary to prevent the harm or damage caused by the establishment of an exotic pest.

RATE OF APPLICATION — The amount of pesticide applied to a plant, animal, unit area or surface; usually measured as per acre, per 1,000 square feet, per linear foot or per cubic foot.

REENTRY INTERVAL — The length of time following a pesticide application when entry into the treated area is restricted.

REGISTERED PESTICIDES — Pesticide products that have been registered by the Environmental Protection Agency for the uses listed on the label.

REPELLENT — A compound that keeps insects, rodents, birds or other pests away from humans, plants, domestic animals, buildings or other treated areas.

RESIDUAL PESTICIDE — A pesticide that continues to remain effective on a treated surface or area for an extended period following application.

RESIDUE — The pesticide active ingredient or its breakdown product(s) remaining in or on the target after treatment.

RESISTANCE — The inherited ability of a pest to tolerate the toxic effects of a particular pesticide.

RESTRICTED-USE PESTICIDE (RUP) — A pesticide that can be purchased and used only by certified applicators or persons under their direct supervision; pesticide classified for restricted use under FIFRA, Section 3(d)(1)(C).

RHIZOME — An underground stem capable of sending out roots and leafy shoots.

RISK — A probability that a given pesticide will have an adverse effect on humans or the environment in a given situation.

RODENTICIDE — A pesticide used to control rodents.

RUNOFF — The movement of water and associated materials on the soil surface. Runoff usually proceeds to bodies of surface water.

SANITATION — The removal of infected plant parts, decontamination of tools, equipment, hands, etc.

SCLEROTIA — A mass of hyphae and food that allows a fungus to survive long periods of extreme hot or cold temperatures and lack of water.

SCOUTING — Regular monitoring of a crop or site to determine possible pest problems.

SCUTUM — Shieldlike structure located near the front part of the ***mesothorax*** of an insect.

SIGNAL WORDS — Required word(s) that appear on every pesticide label to denote the relative toxicity of the product. Signal words are DANGER-POISON, DANGER, WARNING and CAUTION.

SITE — Areas of pest infestation. Each site should be treated specifically or individually.

SOIL DRENCH — To soak or wet the ground surface with a pesticide. Large volumes of the pesticide mixture are usually needed to saturate the soil to any depth.

SOIL FUMIGANT — A toxic gas or volatile substance that is used to kill soil microorganisms.

SOIL INCORPORATION — The mechanical mixing of a pesticide product with soil.

SOIL INJECTION — The placement of a pesticide below the surface of the soil; common application method for nematicides.

SOLUTION — A mixture of one or more substances in another substance (usually a liquid) in which all the ingredients are completely dissolved. Example: sugar in water.

SOLVENT — A liquid that will dissolve another substance (solid, liquid or gas) to form a solution.

SPECIES — See ***taxonomy***.

SPORANGIA — A structure that produces spores.

SPORE — The reproductive stage of a fungus.

SPRAY DRIFT — Movement of airborne spray from the intended area of application.

STOLON — An aboveground creeping stem that can root and develop new shoots.

STOMACH POISON — A pesticide that must be eaten by a pest to be effective; it will not kill on contact.

STYLET — A long, slender, hollow feeding structure of nematodes and some insects.

SUPPLEMENTAL LABELING — Pesticide label information that appears on a separate piece of paper and contains information regarding the site, pest, rate, etc. Supplemental labeling may be supplied at the time of purchase or requested from the dealer.

SURFACE WATER — Water on the earth's surface: rivers, lakes, ponds, streams, etc. (See also ***groundwater***.)

SUSPENSION — Pesticide mixture consisting of fine particles dispersed or floating in a liquid, usually water or oil. Example: wettable powders in water.

TARGET — The plants, animals, structures, areas or pests at which the pesticide or other control method is directed.

TAXONOMY — The classification of living organisms into groups: kingdom, phylum, class, order, family, genus and species.

TECHNICAL MATERIAL — The pesticide active ingredient in pure form as it is manufactured by a chemical

company. It is combined with inert ingredients or additives in formulations such as wettable powders, dusts, emulsifiable concentrates or granules.

THORAX — The middle part of an insect's body, between the head and the abdomen. It is divided into three segments — ***prothorax***, ***mesothorax*** and ***metathorax***. A pair of legs is attached to each thoracic region.

THRESHOLD — A level of pest density at which the pest or its damage becomes unacceptable and control measures are required.

TOXIC — Poisonous to living organisms.

TOXICANT — A poisonous substance such as the active ingredient in a pesticide formulation.

TOXICITY — The ability of a pesticide to cause harmful, acute, delayed or allergic effects; the degree or extent to which a chemical or substance is poisonous.

TOXIN — A naturally occurring poison produced by plants, animals or microorganisms. Examples: the poison produced by the black widow spider, the venom produced by poisonous snakes and the botulism toxin

produced by bacteria.

UNCLASSIFIED PESTICIDE — See ***general-use pesticide***.

USE — The performance of pesticide-related activities requiring certification include: application, mixing, loading, transport, storage or handling after the manufacturing seal is broken; care and maintenance of application and handling equipment; and disposal of pesticides and their containers in accordance with label requirements. Uses not needing certification: long-distance transport, long-term storage and ultimate disposal.

VAPOR PRESSURE — The property that causes a chemical to evaporate. The higher the vapor pressure, the more volatile the chemical or the easier it will evaporate.

VECTOR — A carrier, an animal (e.g., insect, nematode, mite) that can carry and transmit a pathogen from one host to another.

VERTEBRATE — Animal characterized by a segmented backbone or spinal column.

VIRUS — Ultramicroscopic parasites composed of proteins. Viruses can multiply only in living tissues and

cause many animal and plant diseases.

VOLATILITY — The degree to which a substance changes from a liquid or solid state to a gas at ordinary temperatures when exposed to air.

WATER TABLE — The upper level of the water-saturated zone in the ground.

WETTABLE POWDER — A dry pesticide formulation in powder form that forms a suspension when added to water.

ZOOSPORE — A mobile spore with a "tail" enabling it to swim when a layer of moisture is present.

For further definition of terms, consult:

Pesticide Applicator Core Training Manual, E-2195, Michigan State University Extension.

The Federal Insecticide, Fungicide and Rodenticide Act, as amended. Public Law 92-516, October 21, 1972, as amended by Public Law 94-140, November 28, 1975, and Public Law 95-396, September 30, 1978.

Federal Register, November 7, 1990, Part II Environmental Protection Agency 40, CFR Part 171 Certification of Pesticide Applicator; Proposed Rule.

Region V Office of the EPA, Chicago, Ill.

MICHIGAN DEPARTMENT OF AGRICULTURE

Pesticide & Plant Pest Management Division

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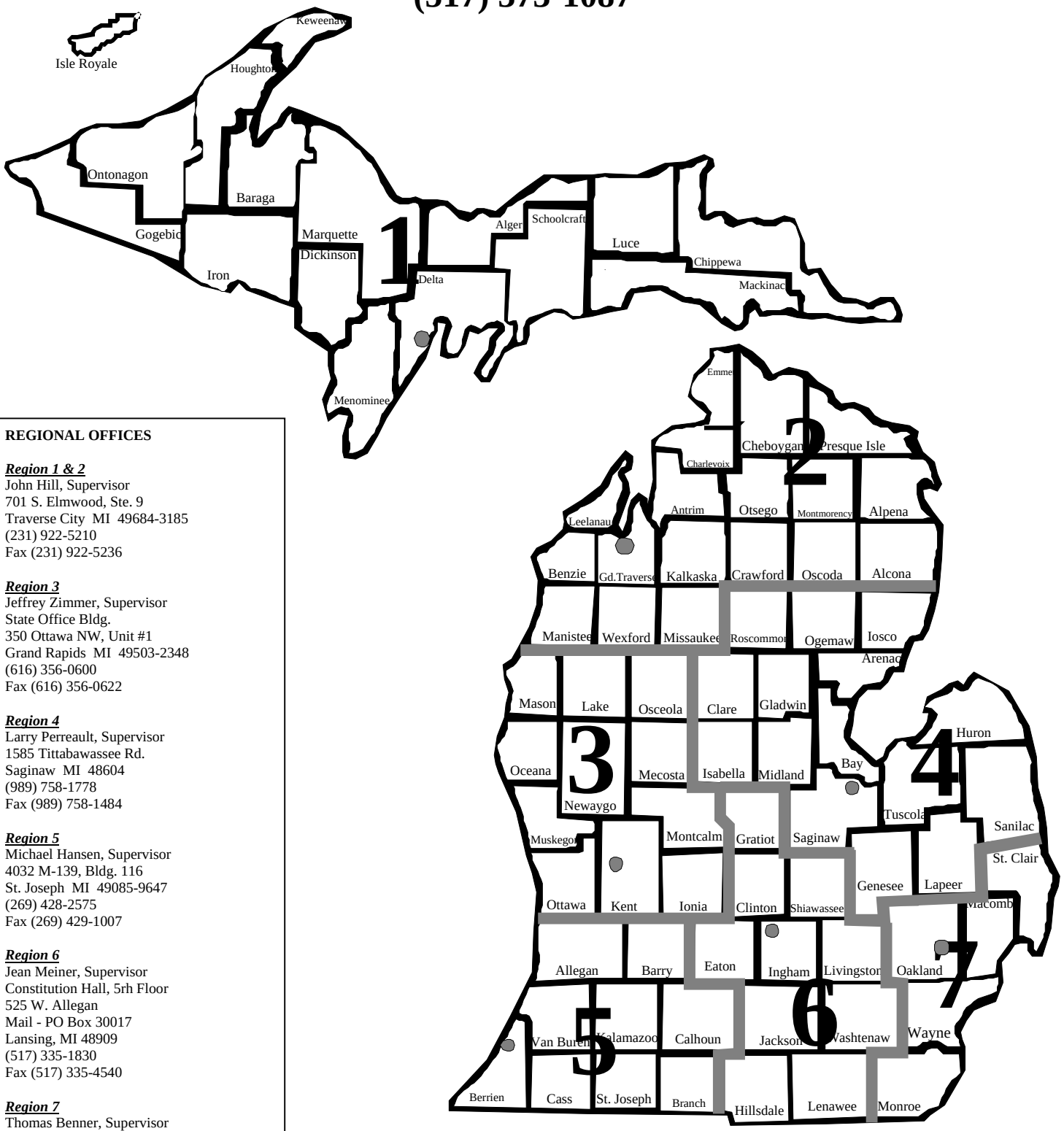

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PESTICIDE EMERGENCY INFORMATION

For any type of an emergency involving a pesticide, immediately contact the following emergency information centers for assistance.

Current as of June 2005

Human Pesticide Poisoning

POISON CONTROL

From anywhere in the United States, call

1-800-222-1222

Special Pesticide Emergencies

Animal Poisoning

Your veterinarian:

_____
Phone No.

or

Animal Poison Control Center ($50 consultation fee per case)

****1-888-426-4435***

www.aspca.org

Pesticide Fire

Local fire department:

_____
Phone No.

and

****911***

Traffic Accident

Local police department or sheriff's department:

_____
Phone No.

and

Operations Division, Michigan State Police:

****(517) 336-6605***

Environmental Pollution

District Michigan Department of Environmental Quality (MDEQ) Office Phone No.

_____
Phone No.

and

MDEQ Pollution Emergency Alerting System (PEAS):

****1-800-292-4706***

also

****1-800-405-0101***

Michigan Department of Agriculture Spill Response

Pesticide Disposal Information

Michigan Clean Sweep, Michigan Department of Agriculture Environmental Stewardship Division.

Monday – Friday: 8 a.m.–5 p.m.

(517) 241-0236

National Pesticide Information Center

Provides advice on recognizing and managing pesticide poisoning, toxicology, general pesticide information and emergency response assistance. Funded by EPA, based at Oregon State University

7 days a week; excluding holidays

6:30 a.m. – 4:30 p.m. Pacific Time Zone

1-800-858-7378

FAX: 1-541-737-0761

Web: npic.orst.edu

**** Telephone Number Operated 24 Hours***

Revised by Carolyn J. Randall, *Pesticide Education Program, Michigan State University Extension*