Aquatic Pest Management - A Training Manual for Commercial Pesticide Applicators (Category 5)
Michigan State University Extension Service
Julie Stachecki, Editor
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Aquatic Pest Management

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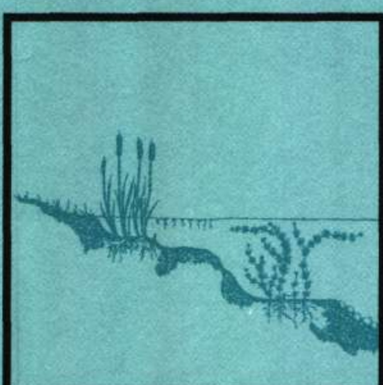

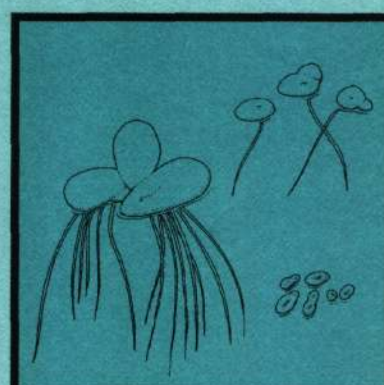

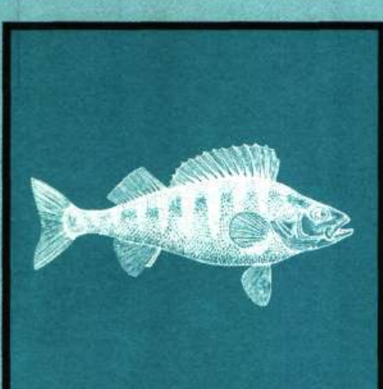

ATTENTION

Recent revisions (July 1993) to the Michigan Pesticide Control Act, Act 171, P.A. of 1976 as amended, limits the scope of persons required to be certified or registered pesticide applicators. This revision affects information found on pages 6, 7 and 12 of this manual (E-2437).

Persons who use pesticides for a non-licensed, commercial purpose and who apply general use pesticides directly from the manufacturer's container (i.e. "ready-to-use") are exempt from certification or registration requirements. Aerosols, pump sprays, strips, ready-to-use baits, etc. are included in the "ready to use" group. A person who applies pesticides for hire (license required) is not exempt.

Also, when property owners use pesticides other than general use, ready-to-use products they are no longer exempt from certification or registration because the statement "on the property of another" has been stricken from Section 13b.(1) of the Act.

For further clarification of Act 171 revisions, contact your regional MDA office.

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Aquatic Pest Management

A Training Manual for Commercial Pesticide Applicators (Category 5)

Julie A. Stachecki, Editor

Contributors

Don Garling, Department of Fisheries and Wildlife, Michigan State University, East Lansing, MI

Richard Hinterman, Cygnet Enterprises, Inc., Linden, MI

Scott Jorgensen, Aquatic Technologies, Inc., Howell, MI

Dave Kenaga, Inland Lakes Management Unit, Land and Water Management Division, Michigan Department of Natural Resources, Lansing, MI

K.A. Langeland, IFAS, University of Florida, Gainesville, FL

William McClay, Fisheries Division, Michigan Department of Natural Resources, Lansing, MI

Steve Metzer, Charter Township of West Bloomfield, West Bloomfield, MI

Larry G. Olsen, Pesticide Education Coordinator, Michigan State University, East Lansing, MI

G. Douglas Pullman, Aquest Corp., Flint, MI

Brian Rowe, Pesticide and Plant Pest Management Division, Michigan Department of Agriculture, Lansing, MI

Jim Schmidt, Applied Biochemists, Inc., Milwaukee, WI

Julie A. Stachecki, Pesticide Education Program, Michigan State University, East Lansing, MI

Ned Walker, Department of Entomology, Michigan State University, East Lansing, MI

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INTRODUCTION

Welcome to the world of aquatic pest management. Aquatic pests may include algae, macrophytes (rooted and non-rooted plants), invertebrates and vertebrates. These organisms may become pests when they interfere with the economic, environmental or recreational uses of a body of water. Interference may take the form of unsightly algae; dense growths of aquatic plants impeding swimmers and boats; leeches and blood flukes that discourage swimmers; or carp that dominate shallow areas of a lake during the spring and ruin the habitat for more desirable fish.

Though you may be familiar with land-based pest management techniques, you will find that aquatic pest management techniques are different. While many aquatic pesticide application techniques are similar, the management plans and goals for each water body are often different because each water body is unique. The primary goals of an aquatic pest management program may include uninhibited recreation, improved appearance and habitat restoration.

As a member of the aquatic pesticide application industry, you need to develop the knowledge and skills to recognize:

- If an organism is a pest.
- What caused the pest to become a nuisance.
- The life cycle of the pest.
- Which life stage of the pest is susceptible to your management strategies.
- Various management techniques and tools, including pesticides, suitable for aquatic uses.
- How nontarget organisms may react to a proposed management strategy.
- The changing conditions of the aquatic environment in which you work.

When working on the water, you must be prepared to interact with people having many interests, people ranging from the once-a-year angler to year-round residents, and those who favor use of chemicals and those who oppose their use. As a pesticide applicator, you are often the first person to whom these people direct their questions and concerns. Often, these persons ask questions to satisfy their curiosity. If applicators do not thoroughly understand the principles of aquatic pest management and the related equipment, they can project a negative image of themselves and the aquatic industry.

The purpose of this manual is to help you learn about the highly specialized area of aquatic pest management. Only by being properly prepared can you expect to perform your duties safely and effectively.

CHAPTER 1

LAWS AND REGULATIONS

Pesticide use in the United States increased from approximately 300 million pounds of active ingredients in 1964 to approximately 1 billion pounds of active ingredients in 1991. Approximatley 275 million pounds of active ingredients were used for nonagricultural purposes in 1991. New, highly sensitive measuring devices are able to detect pesticides in the environment where they were not initially applied. To protect the environment and human health, federal and state laws regulate the proper, safe use of pesticides.

To implement aquatic pest management strategies, you must obtain permits from the Michigan Department of Natural Resources in most cases. Pesticide applicators must have a working knowledge of the laws and regulations governing pesticide use for the safety of the client, themselves and the environment. Knowledge of regulatory guidelines demonstrates an applicator's proficiency and concern for safe procedures. Because the laws and their administrative rules may change, be sure to contact the appropriate authorities before beginning any pest management treatment. Some local units of government (townships, cities or villages) have enacted regulations that govern pesticide applications within their geographic and/or administrative boundaries. Applicators are responsible for knowing these regulations to avoid violations. In this chapter you will learn about the state and federal laws regulating all pesticide applicators and some laws specific to the aquatic pesticide applicator.

Federal Law

Several federal laws regulate pesticide use. Both state and federal agencies enforce these laws. The federal law regulating pesticides is the **Federal Insecticide, Fungicide and Rodenticide Act (FIFRA)**, enacted in 1947 and amended in 1972, 1978 and 1988. FIFRA provides states the authority to certify applicators, register pesticides and design programs to meet local needs. More detailed information about FIFRA provisions and who enforces them is located in the chapter **"Pesticide Laws and Regulations"** of the *Commercial and Private Pesticide Applicator Core Manual: Certification and Registered Technician Training*, Extension bulletin E-2195, available from Michigan State University Extension, 10 Agriculture Hall, East Lansing, MI 48824. This manual is also available in Spanish (E-2195-SP).

State Laws

The primary act regulating pesticides and their use in Michigan is the **Pesticide Control Act, Public Act 171 of 1976.** This act was amended in 1988. Another law regulating the use of aquatic herbicides is the Public Health Code, PA 368 of 1978, also known as the Aquatic Nuisance Control Act. This law establishes procedures for managing aquatic pests with pesticides, which are detailed later in this chapter.

The Michigan Pesticide Control Act gives the director of the Michigan Department of Agriculture (MDA) authority to register or certify private and commercial applicators and to prescribe standards for certification and registration.

A **private applicator** is a person using or supervising the use of restricted use pesticides (RUP) to produce an agricultural commodity on their own or their employer's land, or on lands rented by them.

A **commercial applicator** is any person applying pesticides other than private applicators. There are two subclasses of commercial applicators:

Subclass A - Any person (including homeowners) who uses or supervises the use of RUPs for a nonagricultural purpose.

Subclass B - Any person who applies pesticides in the course of his or her employment on the property of others.

Applicators included in subclass A must be *certified* as commercial applicators. Those in subclass B have the option of becoming certified commercial applicators or registered technicians. Because pesticides are used in a wide variety of operations, commercial applicators are certified or registered in special commodity or site-specific categories. In Michigan, a person applying pesticides to bodies of water must be certified or registered in **category 5, aquatic pest management.**

Certified Commercial Pesticide Applicator

To become a **certified commercial pesticide applicator,** a person must pass a "core" examination and an examination specific to the industry or site he/she will be servicing. A person can be certified in several categories.

When commercial applicators use a restricted use pesticide with a label that requires direct supervision, a certified applicator must make the application or supervise the restricted use pesticide application by being physically present at the time and place the pesticide is applied.

Once a person has become a certified commercial applicator, he/she may make commercial pesticide applications for three years. At the end of the three-year period, applicators must be **recertified** to continue applying pesticides commercially. There are two options for becoming recertified.

Recertification

One option is to pass a recertification exam, administered by the MDA, specific to the category(ies) in which the applicator was initially certified. An applicator may also become recertified by a process referred to as **"recertification by training meeting attendance."** During the three-year certification period, pesticide applicators may earn credits toward recertification by attending preapproved pesticide application seminars. If by the end of the three-year certification period the applicator has earned the proper number of credits, he or she will be recertified without an exam. To be recertified in the aquatic pest management category, an applicator must earn 18 credits during the three-year certification period. **Note:** the seminars must pertain to the category in which the applicator is certified.

It is the pesticide applicator's responsibility to track the credits earned. MDA also maintains a record of credits earned based on seminar sign-in sheets. After three years, the applicator receives an MDA recertification packet and simply mails the recertification fee and the record of the pesticide training meetings attended to the MDA's Lansing office. MDA will compare its credit records with those on the applicator's record. MDA will review any discrepancies by examining the training meeting sign-in sheets to verify attendance.

For more information on the recertification process, contact a regional MDA office or the MDA office in Lansing.

Registered Technician

The 1988 amendments to the Michigan Pesticide Control Act established a new category of applicators called **registered technicians.** This category is for people who are not *certified* applicators but are authorized to apply general use pesticides for a commercial purpose or apply general use pesticides as a scheduled and required work assignment while employed on the property of another person for any purpose. Registered technicians may apply RUPs only after applying the RUP under direct supervision for a specific number of hours if allowed by the specific product label. The intent of this portion of the act is to establish minimum competency standards for all commercial applicators.

To become a registered technician, a person must pass a "core" pesticide examination that tests a person's knowledge on general pesticide information found in the *Commercial and Private Pesticide Applicator Core Manual: Certification and Registered Technician Training,* E-2195. Next, the person must undergo category-specific training designed to deliver specific information to prepare him/her for job tasks. The training must be approved by the MDA and administered by an MDA approved trainer.

All employees of golf courses, hospitals, schools, municipalities and licensed pesticide application businesses, such as aquatic pest management companies, who apply pesticides must be either certified applicators or registered technicians.

For more information about pesticide certification, registered technicians, registered technician training or "approved trainers," contact the Michigan Department of Agriculture, Pesticide and Plant Pest Management Division. P.O.Box 30017, Lansing, MI 48909, (517) 373-1087.

Commercial Pesticide Application Business License

Any business established to apply pesticides for hire must obtain a **commercial pesticide applicator license** by sending an application and fee to

MDA. Such businesses must employ at least one certified commercial applicator with two years of experience or one year of experience and a related four-year college degree, before the license can be issued. The certified applicator supervises the use of any general use or restricted use pesticides by registered technicians. (Note that the business is licensed, not the applicator.) The business must also provide proof of insurance as required by Regulation 636.

The MDA is responsible for investigating pesticide misuse and failures of pesticides to perform when used in accordance with label instructions. If you have a complaint involving a pesticide, notify the nearest MDA office immediately. Delays in making a complaint greatly reduce the chances of a satisfactory investigation. The MDA must receive the complaint within 60 days of the action.

State Law: Regulation 636 – Pesticide Applicators

In 1991, Regulation 636 of Act 171 of 1976 was passed as part of the Michigan Pesticide Control Act amendments of 1988. This regulation directly affects those persons and businesses that apply pesticides to manage aquatic pests. The following are excerpts of the primary components of Regulation 636 of Act 171 and are not intended to represent the entire regulation. Read the actual document for details.

Recordkeeping Requirements

All commercial applicators shall maintain records of pesticide use for a time period not less than the following:

-**General Use Pesticides.** One year following the application.

-**Restricted Use Pesticides.** Three years following the application.

The records shall contain the following:

A) The name and concentration of the pesticide applied.

B) The amount of pesticide applied.

C) The target pest or purpose.

D) The date the pesticide was applied.

E) The address or location of pesticide application.

F) Where applicable, the method of application.

These pesticide records must be made available to MDA upon request.

Registered Technician Classification

Registered technician is now the minimum competency standard for pesticide applicators as explained above. Part of Regulation 636 and the registered technician program involves **approved trainers.**

Approved Trainers

Approved trainers are certified applicators with two years of experience in the category in which they intend to train and have participated in a designated seminar to earn credentials making them eligible to train registered technicians.

Incidental Use

Regulation 636 also provides an exemption from some provisions of the act for **incidental use.** Individuals or firms must request from the MDA in writing, an exemption to the registered technician or certified applicator requirement if they meet the following conditions:

- A general use pesticide is used;
- The person is not regularly engaged in the application of pesticides for hire;
- The pesticide application is an integral part of another operation.

State Law: Regulation 637

Regulation 637 of the Michigan Pesticide Control Act affects commercial pesticide applicators and their pest management operations in several ways. Regulation 637 became effective October 29, 1992. The rules of Regulation 637 include:

RULE –

1-3) Establishes definitions and terms.

4) Requires specific conduct of pesticide applicators to protect people and the environment.

5) Establishes a registry of persons who require notification prior to pesticide applications made on adjacent properties.

6-7) Requires the use of containment structures for certain mixing/loading and washing/rinsing operations.

8) Defines acceptable means for disposing of pesticides and pesticide-containing materials.

9) Requires the use of protective equipment.

10) Addresses avoidance of off-target drift and use of Drift Management Plans.

11) Calls for the posting of certain areas treated

with pesticides and notification of the public prior to right-of-way and community pesticide applications.

12) Requires the use of service agreements.
13) Prohibits false claims regarding pesticide safety.
14) Requires applicator training in integrated pest management and use of IPM programs in certain areas.
15) Describes manners of pesticide use in and around schools.
16) Establishes a registry of certified organic farms.

It is vital that all commercial pesticide applicators obtain a copy of Regulation 637 to understand the components of each rule and how commercial pest management practices must comply.

State Law: Public Health Code, Act 368 of 1978 (Aquatic Nuisance Control Act) and the Michigan Department of Natural Resources

To treat a body of water with a pesticide, one must comply with the state laws discussed above, and with the **Public Health Code, Act 368 of 1978,** also known as the **Aquatic Nuisance Control Act,** and the administrative rules declared under that act. This act is administered by MDNR and pertains to any person proposing a chemical treatment for the control of aquatic nuisances in Michigan waters, except certain ponds. **A pond, as defined by this act, is a body of water less than 10 acres in size, has one owner and has no outlets.** Individuals, certified applicators, government units and lake associations are subject to the requirements of this act, which is administered and enforced by the Michigan Department of Natural Resources.

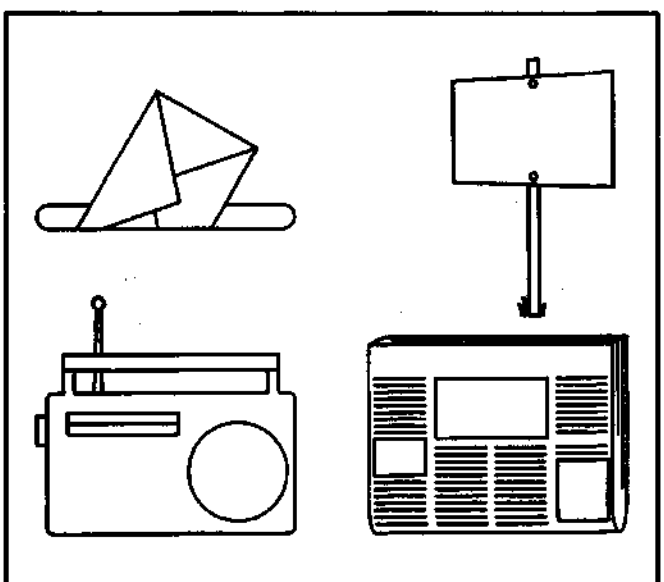
The following information is part of the Aquatic Nuisance Control Act but is not intended to represent the entire regulation. Obtain the actual document for details.

- A permit must be obtained from the Michigan Department of Natural Resources (MDNR) to use registered chemicals for aquatic nuisance management. Aquatic nuisance means any organism that lives or propagates, or both, within the aquatic environment and interferes with or impairs the use or enjoyment of the aquatic resources of Michigan.
- Applying for a permit requires:
  - Appropriate MDNR forms (a sample application for an aquatic nuisance control permit is found in Appendix B of this manual).
  - A drawing of the treatment area (two copies).
  - Name of applicator or lake association engaging in the treatment; if the treatment involves the property of five or more riparian owners, a list of not fewer than five individual riparian owners involved in the treatment must accompany the application for a permit.
  - Permits for aquatic herbicide use will be issued **only after April 1. No permits for higher aquatic life are issued after August 20,** although permitted treatments may continue until December 31.
- A permit application proposing treatment of a body of water or a connecting watercourse that serves as a municipal water supply will be reviewed by the Michigan Department of Public Health.
- The aquatic pest manager is **required** to complete posttreatment reports for all permits issued by MDNR to execute aquatic-related work. These post-treatment reports are to be sent to MDNR at the end of each season for which the permit was issued. If no treatment was made for a particular permit issued, a posttreatment report is still required.
- Reasons the MDNR may *deny* a permit include:
  - The application for the permit was submitted after August 20.
  - The proposed use of the pesticide was inconsistent with the label or MDA registration.
  - The use of an aquatic herbicide, though strictly in accordance with the label and otherwise in compliance with the Aquatic Nuisance Control Act, is likely to result in economic loss, recreational damage or public health hazard.
  - The permit application proposes treatment of an excessively large quantity of rooted aquatic vegetation of any one lake as determined by the MDNR.

Following the issuance of a permit by the MDNR to the permit applicant, the following conditions apply:

- The applicator ***must give notice*** of the proposed treatment in writing not less than seven days prior to the treatment to all persons whose land is within the treatment area and all occupants of adjacent riparian dwellings whose bottomlands are within the treated area or within 100 feet of the treated area.

- The pesticide applicator *may* be required to notify the MDNR office that is specified on the issued permit (typically the local regional office) of the precise chemicals to be used and the location of the treatment at least two working days prior to the actual treatment.
- The permit *may* require that an MDNR representative be present during the application.
- The applicator *may* be requested to supply the MDNR or its representative a sample of the pesticide used prior to or during the pesticide treatment.
- The area to be treated *may* need to be posted prior to the treatment according to the precautions printed on the permit and/or according to the posting guidelines listed below.
- The permittee *may* be required to publish a notice in a local newspaper or make an announcement on a local radio station that outlines the chemical used, a description of the treated area and the restrictions on the use of the treated water.



Pesticide applicators may be required to use several methods for communicating information about a pesticide application.

- The permittee is *required* to complete and return an MDNR treatment report form on or before November 1 of the year in which the permit was issued. These reports are required even if no treatment was performed.

A sample permit for pesticide application to surface waters of Michigan is included in Appendix B of this manual.

Two state laws require notification and posting of pesticide-treated areas. These laws regulate different groups of applicators. Regulation 637 has established guidelines for pesticide applications involving ornamental plant and turf treatments, right-of-way, gypsy moth and mosquito treatments. Aquatic pest managers must comply with the administrative rules of the **Aquatic Nuisance Control Act.** Listed below is an overview of the rules for posting aquatic areas.

- For treatment areas less than 2 acres, signs incorporating the posting instructions on the permit shall be posted along the shoreline of the treatment area not more than 100 feet apart. To allow for drift of chemical from the treatment area, riparian lands adjacent to the area shall also be posted, if allowed by the riparian owners.
- For treatment areas in excess of 2 acres, signs shall be posted as stated above. In addition, all access sites, boat launching areas, and private and public parks located on the body of water involved shall be noticeably posted, such as at entrances, boat ramps and bulletin boards. If these sites, launching areas and parks are not to be treated or are not adjacent to a treated area, the signs shall clearly indicate the location of the treatment area and shall outline the restrictions on the use of the water in that treatment area. Restrictions may include swimming or bathing, household uses, irrigation, stock watering or similar uses and the taking of fish for food or feed.
- The MDNR must approve the printed signs used for posting information relating to aquatic pesticide applications. The signs must include the following information:
  - The MDNR permit number.
  - The name, address, and telephone number of the person, organization, or certified applicator conducting the treatment.
  - The brand name(s) of the chemical or chemicals.
  - Restrictions on the use of the treated water.
  - The date of the application.

State Law: Act 245 of 1929, The Water Resources Commission Act

The Water Resources Commission Act, Public Act 245 of 1929 as amended, may also affect the commercial pesticide applicator. Rule 1097 of the act states: "The application of materials for water resource management projects pursuant to state statutory provisions is not subject to the standards prescribed by these rules, but all projects shall be reviewed and approved by the Commission before application." Outside the permitted treatment area, as defined in the Act 368 permit application, the provisions of Section 1057 of Act 245, the Water Quality Standards Act, apply.

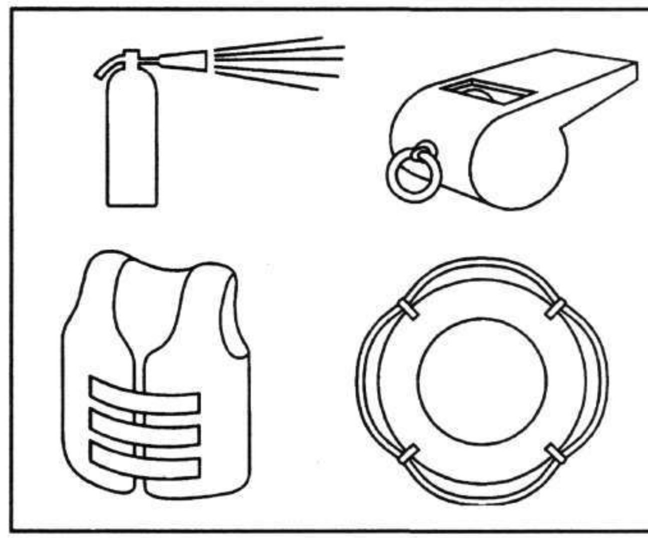
Section 323.6 (a) of this law states: "It is unlawful to directly or indirectly discharge any substance to the waters of the state which is or may become injurious to the public health, safety or welfare; or which is or may become injurious to domestic, commercial, industrial, agricultural, recreational, or other uses which are being or may be made of such waters; or which is or may become injurious to the value or utility of riparian lands; or which is or may become injurious to livestock, wild animals, birds, fish, aquatic life, or plants or the growth or propagation thereof be prevented or injuriously affected; or whereby the value of fish and game is or may be destroyed or impaired." Treatments performed without an Act 368 permit, or that result in damage to the environment outside the Act 368 permitted treatment, can result in fines up to $25,000 per day.

Boating Regulations

Aquatic pesticide applicators work under different conditions than other commercial pesticide applicators. Rather than driving a tractor, walking across a lawn or flying over a crop, the aquatic pesticide applicator is usually in some type of boat. Michigan and federal laws governing general watercraft operation must be followed.

Keep your boat in legal working condition. Be familiar with the requirements in the Marine Safety Act, Act 303 PA 1967 as amended, and its rules. A few of the important requirements are:

1. The boat must be properly registered. Registrations are obtained at any Secretary of State office and are valid for three years.
2. The boat must be equipped with one readily available personal flotation device (life jacket or seat cushion) per passenger. If your pesticide applications require you to work over the edge of the boat, it is recommended that you wear the personal flotation device during applications and have an extra one on board.
3. The boat must have proper running lights in working order. These are critical if your work requires applications before dawn or into the evening.
4. A fire extinguisher appropriate for the vessel must be on board. It is recommended that a fire extinguisher appropriate for the pesticides you are using also be on board.
5. A sound device such as a horn, bell or whistle that can be heard for at least one-half mile is also required.



Have the required safety equipment on board your boat.

Weed harvesters are considered boats and must meet all the requirements for their size and class.

Though you are engaged in commercial work, your vessel is not considered a commercial vessel. In Michigan, the only boats that must be registered as commercial are livery boats, commercial fishing boats and boats carrying passengers for hire.

If a personal floatation device becomes splashed or contaminated with a pesticide solution, launder it with a heavy-duty liquid detergent in hot water separate from other family wash.

Chapter 1 – Laws and Regulations Review Questions

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

1. The state law regulating pesticides is called FIFRA. True or False?

2. To what agency does the Michigan Pesticide Control Act give the director the authority to register or certify private and commercial applicators and to prescribe standards for certification and registration?
   a. MSU Extension.
   b. Michigan Department of Natural Resources.
   c. Michigan Department of Agriculture.
   d. Public Health Department.

3. Public Act 171 of 1976, also known as the Aquatic Nuisance Control Act, establishes procedures for managing aquatic pests with pesticides. True or False?

4. A person applying pesticides must be either a certified applicator or a registered technician, and the company he/she works for must be licensed to provide pesticide application services. True or False?

5. Registered technicians are persons who are not certified commercial pesticide applicators but are authorized to apply general use pesticides for a commercial purpose. True or False?

6. Any business established to apply pesticides for hire must:
   a. Employ a certified applicator or registered technician.
   b. Obtain a commercial pesticide applicator license.
   c. Keep records of pesticide applications.
   d. All of the above.

7. Regulation 636 expanded the pesticide record-keeping requirements. Records shall contain all of the following EXCEPT:
   a. The name and concentration of the pesticide applied.
   b. The amount of pesticide applied.
   c. The name of the applicator.
   d. The target pest or purpose.
   e. The address or location of the pesticide application.
   f. None of the above.

8. Which of the following is not a component of Regulation 637?
   a. Registry of persons requiring prior notification of the application of pesticides.
   b. Washing and rinsing operations of equipment.
   c. Protective equipment.
   d. Off-target pesticide drift management.
   e. Notification and posting requirements.
   f. Endangered species precautions.
   g. None of the above.

9. Public Health Code, Act 368 of 1978, also known as the Aquatic Nuisance Control Act, pertains to any person proposing a chemical treatment for the control of aquatic nuisances in the waters of the state except certain ponds. True or False?

10. Who administers and enforces the Aquatic Nuisance Control Act?

CHAPTER 2

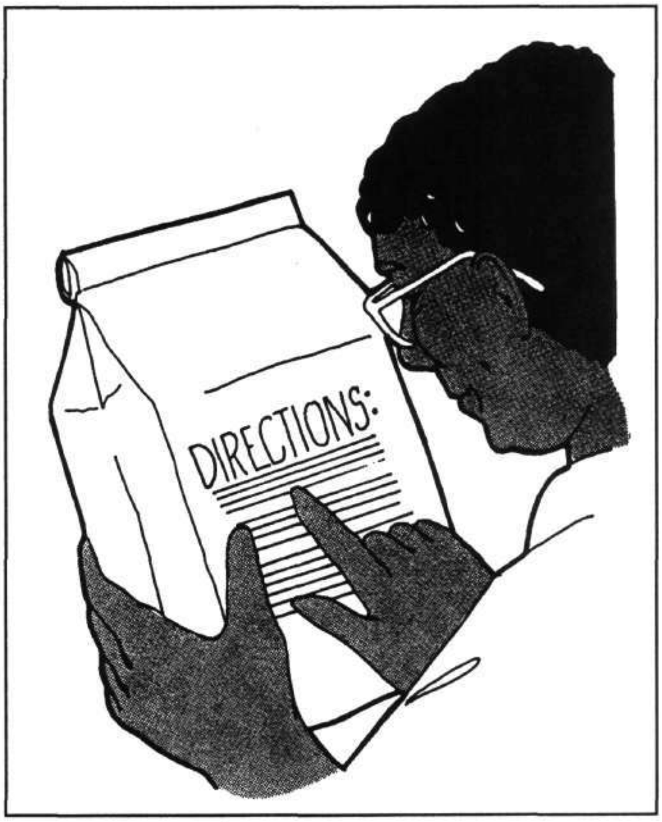
PESTICIDE SAFETY

Pesticides are valuable tools for reducing the impact of pests in aquatic ecosystems. However, if used incorrectly or without full knowledge of the potential hazards they present, pesticides can cause great damage and injury to the applicator, the public, and the environment.

Pesticides are toxic materials. Applicators assume risk every time they choose to use a pesticide. You can minimize risk by having an understanding of:

- How to select the best pesticide for controlling the pest you have identified.
- How to apply the pesticide at the proper time (when the pest is most vulnerable).
- How to protect yourself with appropriate personal protective equipment.
- How to properly mix, load and apply pesticides.
- How to dispose of the container and rinsates.
- How to store pesticides.
- The fate of the pesticides you apply.

Much of this information can be found on the product label. Become familiar with the components of a pesticide label so you can use the information for making decisions about pesticide use.



Read and follow all directions found on pesticide labels.

Pesticide Labeling

Pesticide product labeling is the primary means of communication between a pesticide manufacturer and pesticide users. **Labeling** includes the label itself, plus all other information you receive from the manufacturer about the product when you buy it. **Pesticide users are required by law to comply with all the instructions and directions for use included in pesticide labeling.**

No pesticide may be sold in the United States until the U.S. Environmental Protection Agency (EPA) has reviewed the manufacturer's application for registration and determined that the use of the product will not present an unreasonable risk to humans or the environment when it's used according to label directions. As part of this product registration process, the EPA has set certain labeling requirements and must approve all language that the manufacturer proposes to include in the product labeling. Parts of a label are listed and briefly explained below.

Parts of Pesticide Labeling

Pesticide labeling contains basic information that helps users clearly identify the product.

Brand name — Each manufacturer has a brand name for each of its products. Different manufacturers may use different brand names for the same pesticide active ingredient. The brand or trade name is usually the one used in advertisements and by company salespeople. Pesticide handlers must beware of choosing a pesticide product by brand name alone. Many companies use very similar names with only minor variations to designate entirely different pesticide chemicals. **Always** read the ingredient statement to verify the active ingredients that a product contains.

Ingredient statement — Each pesticide label must list the active ingredients and the amounts of each ingredient (as a percentage of the total product). The ingredient statement must list the official chemical name and/or common name for each active ingredient. Inert ingredients need not be named, but the label must indicate their percentage of the total contents.

The **chemical name** is a complex name that identifies the chemical components and structure of the pesticide. This name is almost always listed in the ingredient statement on the label. For example, the chemical name of Reward is 6,7-dihydrodipyrido(1,2-a:2',1-c)pyrazinediium dibromide.

Because pesticides have complex chemical names, many are given shorter common names. Only **common names** that are officially accepted by the U.S. Environmental Protection Agency may be used in the ingredient statement on the pesticide label. The official common name may be followed by the chemical name in the list of active ingredients. For example, a label with the brand name Sonar would read:

Active Ingredient:

Fluridone: 1-methyl-3-phenyl-5-[3-(trifluoromethyl) phenyl]-4(1H)-pyridinne 41.7%
Inert ingredients.. 58.3%

By purchasing pesticides according to the common or chemical names, you will always be sure to get the right active ingredient.

Registration and establishment numbers — These numbers are needed by the pesticide handler in case of poisoning, claims of misuse, product recalls or liability claims.

Name and address of manufacturer — The law requires the maker or distributor of a product to put the name and address of the company on the label. This is so you will know who made or sold the product.

Net contents — The front panel of the pesticide label tells you how much is in the container. This can be expressed as pounds or ounces for dry formulations and as gallons, quarts, pints, or fluid ounces for liquids. Liquid formulations also may list the pounds of active ingredient per gallon of product (see the above example).

Type of pesticide — The type of pesticide usually is listed on the front panel of the label. This short statement indicates in general terms what the product will control. Three types of pesticides that an aquatic pest manager may encounter include herbicides for weed management, algaecides for algae management, and piscicides for fish management.

Type of formulation — The front panel of some pesticide labels will tell you what kind of formulation the product is, such as granular or liquid.

Restricted Use Designation

When a pesticide is classified as restricted by the EPA, the label will state "Restricted Use Pesticide" (RUP) in a box at the top of the front panel. Below this heading may be a statement describing the reason for the restricted use classification.

The Michigan Department of Agriculture also restricts the use of some pesticides that are not classified as RUPs by EPA. The labels for these products may not bear the statement "Restricted Use Pesticide," e.g., Reward. Consult with your regional MDA office for a list of restricted use pesticides in Michigan.

Front Panel Precautionary Statements

Signal words and symbols — The signal word — DANGER, WARNING or CAUTION — must appear in large letters on the front panel of the pesticide label. It indicates how acutely toxic the product is to humans.

The signal word is not based on the active ingredient alone, but on the contents of the formulated product. It reflects the hazard of any active ingredients, carriers, solvents or inert ingredients. The signal word indicates the risk of acute effects from the four routes of exposure to a pesticide product, oral, dermal, inhalation and eye, and is based on the one that is greatest. Use the signal word to help you decide what precautionary measures are needed for yourself, your workers and other persons who may be exposed.

- **DANGER** — This word signals you that the pesticide is highly toxic. The product is very likely to cause acute illness from oral, dermal or inhalation exposure, or to cause severe eye or skin irritation.
- **POISON/SKULL AND CROSSBONES** — All highly toxic pesticides that are very likely to cause acute illness through oral, dermal or inhalation exposure also will carry the word POISON printed in red and the skull and crossbones symbol. Products that have the signal word DANGER because of skin and eye

irritation potential will not carry the word POISON or the skull and crossbones symbol.

- WARNING — This word signals you that the product is moderately likely to cause acute illness from oral, dermal or inhalation exposure, or that the product is likely to cause moderate skin or eye irritation.
- CAUTION — This word signals you that the product is slightly toxic or relatively nontoxic. The product has only slight potential to cause acute illness from oral, dermal or inhalation exposure. The skin or eye irritation it would cause, if any, is likely to be slight.

Statement of practical treatment (first aid) — Most pesticide products are required to include instructions on how to respond to an emergency exposure involving that product.

Hazards to Humans and Domestic Animals

Acute effects statements — The label or labeling will contain statements that indicate which route of entry — mouth skin, eyes, lungs — you must particularly protect and what specific action you need to take to avoid acute effects from exposure to the pesticide. The statements will warn you if you may be harmed by swallowing or inhaling the product or getting it on your skin or in your eyes.

Many pesticides can cause acute effects by more than one route, so study these statements carefully. These precautionary statements tell you what parts of your body will need the most protection. "DANGER: Fatal if swallowed or inhaled" gives a far different indication than "DANGER: Corrosive — causes eye damage and severe skin burns."

Delayed effects statements — The labeling of pesticides that the Environmental Protection Agency considers to have the potential to cause delayed effects must warn you of that fact. These statements will tell you whether the product has been shown to cause problems such as tumors or reproductive problems in laboratory animals.

Allergic effects statement — If tests or other data indicate that the pesticide product has the potential to cause allergic effects, such as skin irritation or asthma, the product labeling must state that fact. Sometimes the labeling refers to allergic effects as "sensitization."

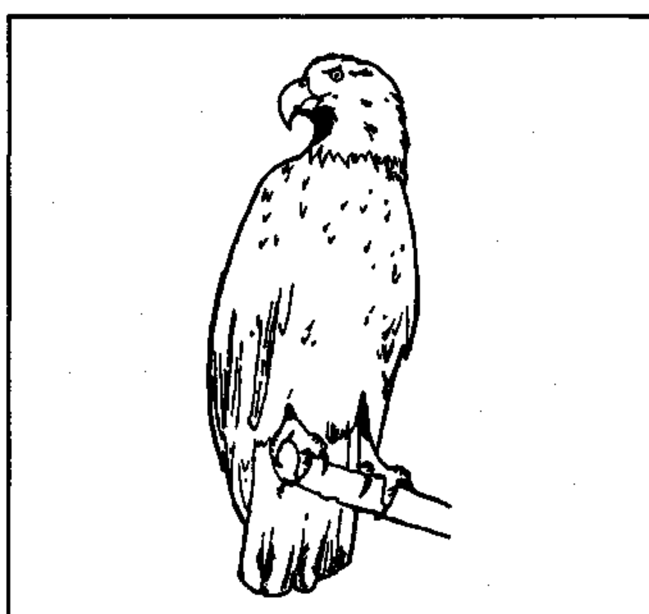
Personal protective equipment statements — Immediately following the statements about acute, delayed and allergic effects, the labeling usually lists personal protective equipment requirements. These statements tell you the minimum personal protective equipment that you must wear when using the pesticide. This includes handling, mixing, loading, working with equipment that contains a pesticide and handling the pesticide containers. Sometimes the statements will require different personal protective equipment for various pesticide handling activities. For example, an apron may be required only during mixing and loading or equipment cleaning.

Environmental Hazards

This section of the pesticide labeling will indicate precautions for protecting the environment when you use the pesticide. The labeling will contain specific precautionary statements if the pesticide poses a specific hazard to the environment. For example, it may warn you that the product is highly toxic to bees, birds, fish or other wildlife.

Directions for Use

Directly under the heading "Directions for Use" on every pesticide product labeling is the following statement: "It is a violation of Federal Law to



The pesticide label may require that special precautions be taken to protect endangered species.

use this product in a manner inconsistent with its labeling." The directions section also contains information on storage and disposal and may contain a section on entry into or use of treated areas/sites after a pesticide application. In addition, it will contain the specific directions for using the product.

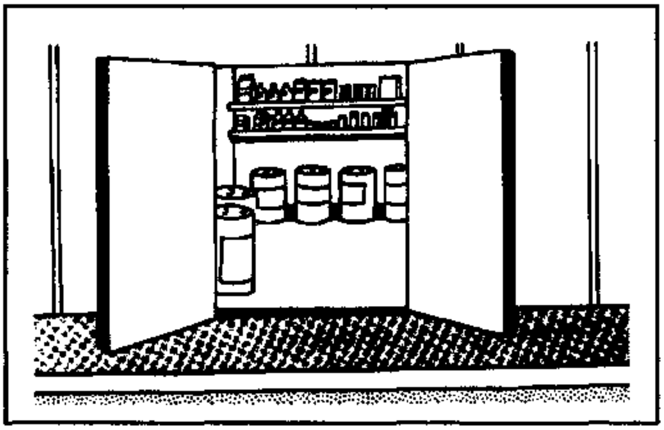
Use inconsistent with the labeling — It is illegal to use a pesticide in any way prohibited by the labeling. You may not use higher dosages, higher concentrations or more frequent applications. You must follow all directions for use, including directions concerning safety, mixing, diluting, storage and disposal. You must wear the specified personal protective equipment. **Use directions and instructions are not advice — they are requirements.** The following are situations that an aquatic applicator may encounter that are not considered uses inconsistent with the label:

- Using the product at a lower rate than the label specifies.
- Mixing two or more pesticides together if it is not prohibited according to label directions.
- Applying the pesticide at the label rate to control a pest when the pest is not listed on the label but the site where the pest is located is on the label and the label does not specifically prohibit treating the pest. "Site" may represent many things, including a host plant or animal, a field, pond, foundation or structure.

Entry statement or use of treated water — Some pesticide labeling contains a precaution about entering a treated area or using treated water after application. This statement tells you how much time must pass before swimming or bathing in treated water or using the treated water for irrigation or consumption; e.g., "Do not use the treated water for animal consumption, spraying, irrigation or domestic purposes for 14 days after treatment."

Michigan applicators are responsible for making information on restricted water use available to water users by posting treated areas and surrounding areas. The permits required for any application of pesticides to Michigan waters may have additional or more stringent requirements than the product labeling. These permits also have posting and notification requirements. Read the "Laws and Regulation" chapter of this manual to learn more about your responsibilities.

Storage and disposal — All pesticide labeling contains some instructions for storing the pesticide and how to dispose of excess pesticide and the pesticide container in ways that are acceptable under federal regulations. For acceptable practices in Michigan, consult pesticide-related laws. Appropriate storage and disposal practices are critical for preventing environmental damage.



Store pesticides in a secured area to prevent human and animal exposure and to ensure the integrity of the products.

Other directions for use — The instructions on how to use the pesticide are an important part of the labeling. Pesticide labels are the best source for determining the appropriate manner for handling the product.

The use instructions will tell you:

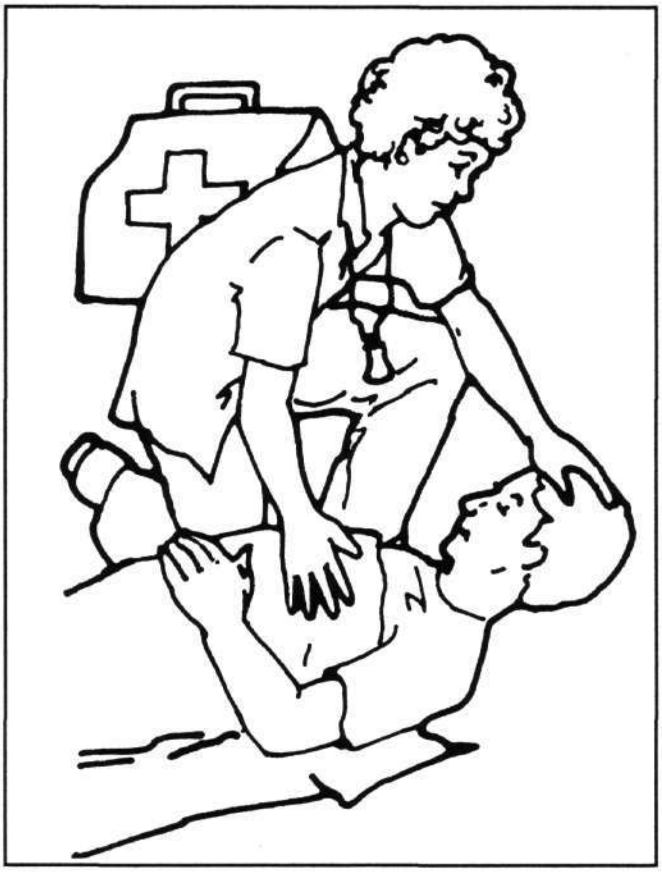
- The pests that the manufacturer claims the product will control.
- The correct equipment to use.
- How much pesticide to use.
- Mixing directions.
- Whether the product can be mixed with other often-used products.
- When, where and how often it should be applied.

PESTICIDES AND HUMAN EFFECTS

Some pesticides are highly toxic to humans — only a few drops in the mouth or on the skin can cause extremely harmful effects, possibly death. Other pesticides are less toxic, but excessive exposure to them can cause harmful effects, too. A useful equation to remember is:

HAZARD = TOXICITY x EXPOSURE

Hazard is the risk of harmful effects caused by pesticides. Hazard depends on both the **toxicity** of the pesticide and the **exposure** you receive in a given situation.



Know the potential effects of pesticides and how to obtain help if an emergency arises.

Toxicity

Toxicity is a measure of the ability of a pesticide to cause harmful effects. Signal words listed on the labels of all pesticides indicate the relative toxicity of the ingredients. These signal words allow us to make informed decisions and take necessary precautions about how we handle, use and dispose of the product according to its toxicity.

Acute toxicity generally describes the immediate (usually within 24 hours) effects of a single short-term exposure to a material.

Chronic toxicity describes delayed effects from repeated exposures. This is determined by exposing test animals, usually rats or mice, to varying amounts of a material over a life span, or often several generations, and observing the results. Effects evaluated in this way include potential tumors, production of malignancy or cancer, and reproductive effects.

Scientists classify ***exposure*** to toxicity according to the way a material gets into our system. There are four primary ways that pesticides come in contact with your body:

- **Dermal** exposure — when you get a pesticide on your skin.
- **Oral** exposure — when you swallow a pesticide.
- **Inhalation** exposure — when you breathe in a pesticide.
- **Ocular** exposure — when you get a pesticide in your eyes.

Managing Risk

Let's look at the hazard/risk equation again:

HAZARD = TOXICITY x EXPOSURE

We can manage the level of hazard by making informed decisions and taking every precaution when working with pesticides. If we recognize that the most important factor that influences toxicity is the dose, or the amount of pesticide that enters the body, we can make decisions to limit the dose by limiting our exposure.

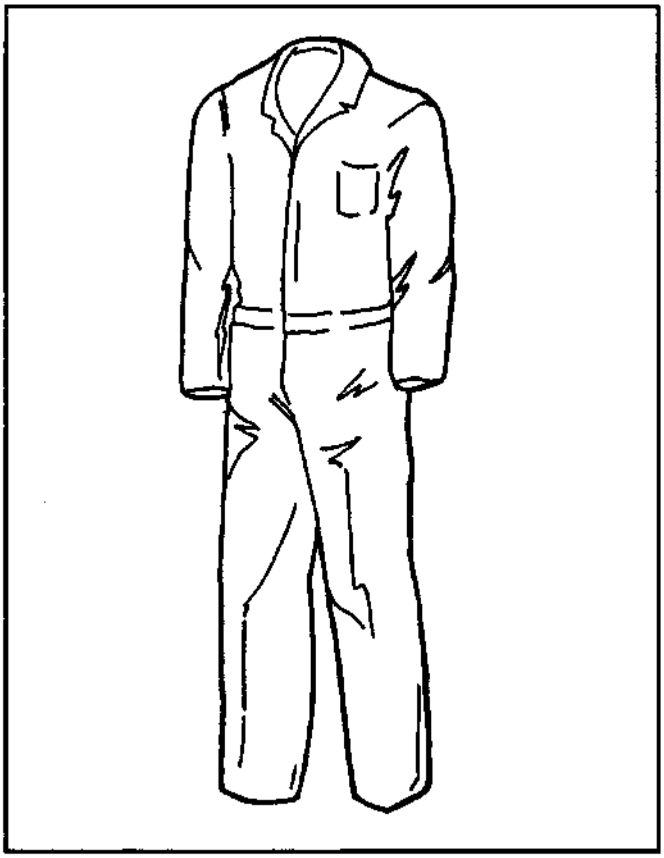
Limiting Exposure

When working with pesticides, be alert, be prepared and exercise every precaution. Handling pesticides without proper protection and common sense can mean unintentional exposure. Consider the unique situations that may arise in your pesticide application because you are in a boat and operating on the water. Your working surface may not be stable when waters are not calm.

Boats may have seats covered in fabric that may absorb pesticides or solutions splashed or spilled on them. Proper and thorough clean-up procedures are vital to avoid accidental exposure to a person who may sit on this surface.

What would happen if a pesticide container is accidentally dropped overboard? If the container floats and has the lid securely attached, your situation is less critical than if a container was open or sinks to the bottom of the lake. Do not dive in after a pesticide that was in an opened or paper container. A person who made such a recovery was severely injured by exposure to the concentrated pesticide dissipating from the package. Avoid exposing yourself to the pesticide. Retrieve the container using proper protective equipment.

Unclothed parts of the body can be directly exposed to the pesticides. While working in warm temperatures and on the water, you may be tempted to wear shorts and a short-sleeved shirt. You are at risk of exposure when making your pesticide applications just as much as the person spraying an apple orchard, a field of corn or the neighbor's front lawn. As we have discussed, pesticides can enter your body through the skin, lungs, eyes and mouth. Dermal exposure accounts for more than 80 percent of pesticide poisoning cases of pesticide applicators.



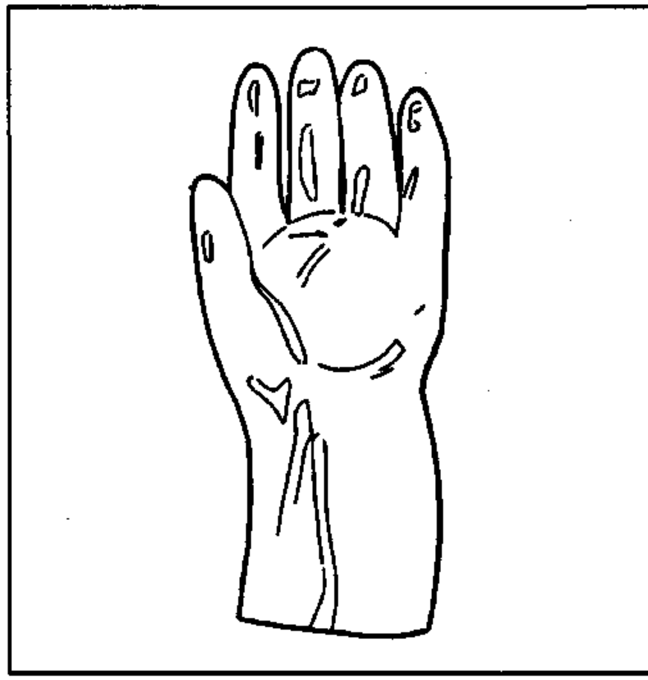
Coveralls help prevent dermal exposure.

Some parts of the body absorb pesticides faster than others and need extra protection. Studies have shown that the head and scrotal areas are highly susceptible to pesticides. The hands are the culprits in the majority of reported pesticide poisonings. Hands can contaminate an individual through direct contact with the pesticide or by indirect contact such as rubbing the eyes. Proper use of gloves can reduce exposure to the hands by 80 percent. Never smoke, eat, drink or use the toilet after handling pesticides without first washing your hands.

Clothing provides protection, but only if it's properly chosen, worn and maintained. Each pesticide situation is unique and requires an individual decision about appropriate **personal protective equipment (PPE).**

Your choice of protective equipment is going to be based on the information from the pesticide label. Read the label! The label is the law. You must wear the recommended garments, but remember: it's ok to wear more!

To fully evaluate the potential hazard of a pesticide, competent applicators look first at its toxicity by locating the signal words, as well as the formulation and route of entry, found on the label. The signal words indicate the general level of protection needed. For most pesticides labeled "Caution," appropriate work attire, gloves and goggles may be sufficient, while those labeled "Danger" require chemical-resistant clothing.



Proper use of gloves can reduce exposure to the hands by 80 percent.

Route of entry information listed under the "Hazards to Humans" section will help you select proper protective equipment. Think carefully and make your decisions. If the label reads "Causes eye irritation" or "Avoid contact with eyes," you should immediately think "Wear goggles and a face shield."

To properly protect yourself from exposure, it is important to understand the protective ability of various fabrics and how to wear the clothing or equipment correctly.

Begin with clean underwear and regular work clothing: long pants, a long-sleeved shirt or coveralls, plus socks and footwear. These garments provide minimum protection against granular pesticides and pesticides labeled "Caution." If these items become saturated with a pesticide concentrate or solution, remove them immediately so your skin does not remain in contact with the chemical. Wash with plenty of soap and water and put on a clean set of clothing.

To get maximum protection with ordinary work clothes, choose fabrics made from 100 percent cotton. Select a twill fabric — one with a diagonal weave such as denim. Select a heavy fabric. New denim will provide more protection than worn denim. Do not wear garments or shoes made of leather — leather absorbs pesticides and cannot be cleaned.

If you expect to be in a situation where a large amount of pesticide could be deposited on your clothing, and if you will be in that situation for a long time, consider wearing a chemical-resistant suit even if the pesticide labeling does not require you to do so.

When an applicator is layered in personal protective equipment, it is easy to become overheated when performing applicator duties. Be careful and monitor your work pace, keeping it moderate and consistent. Take frequent breaks to cool down. Drink plenty of water. Work with another person for safety.

The pesticide labeling may require you to wear a chemical-resistant apron while you are mixing and loading the pesticide and while you are cleaning pesticide equipment. Consider wearing an apron whenever you are handling pesticide concentrates.

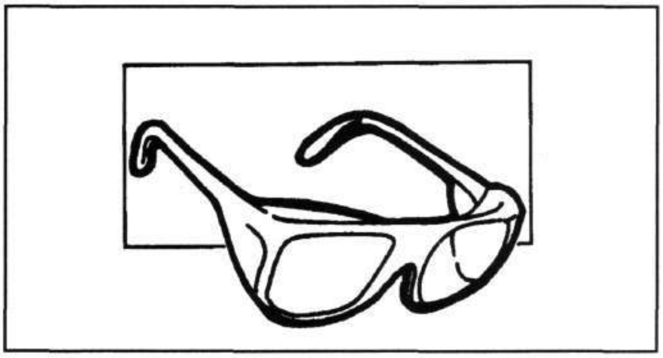
Some pesticide labels may require wearing an apron when mixing or handling pesticides.

It will protect you from splashes, spills and billowing dusts and will protect your coverall or other clothing. Wear an apron over the coverall or long-sleeved shirt and long-legged pants required for application or other handling activities.

The greatest risk to the applicator is in handling and applying highly toxic materials and in mixing and loading pesticide concentrates. Do not tear paper containers to open them; use a sharp knife or scissors. When pouring from a container, keep the container at or below eye level and avoid splashing or spilling on your face or protective clothing. Do not use your mouth to siphon a pesticide from a container. Always stand upwind, or so the wind does not blow the pesticide toward your body.

It is not recommended to wear baseball caps when handling pesticides. They are not chemical-resistant and become a source of repeated contamination because they are worn for many occasions but rarely washed. An aquatic applicator who is exposed to direct sun, glare and reflection off the water, should wear a plastic hard hat or other non-absorbent hat to provide sun protection.

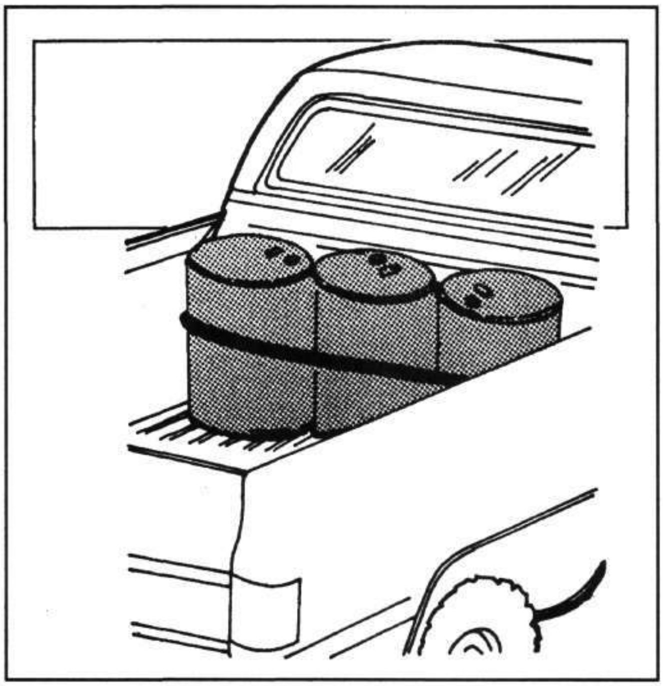
When the pesticide labeling requires you to wear protective eye wear, wear goggles, a face shield or safety glasses with shields at both the brow and sides. Eyes are very sensitive to chemicals in some pesticide formulations, especially concentrates, and temporary blindness caused by an accident may delay or prevent self-treatment. Eyes also readily absorb some pesticides. Do not wear contact lenses when handling pesticides. Instead, wear cover goggles that fit over prescription glasses.



Protect your eyes from pesticides.

Transporting and Handling Pesticides: Be Prepared

Aquatic applicators travel to application sites and transport spray equipment and the pesticides for the job. They must use common sense and follow all safety precautions. Before leaving for a job site read and follow all pesticide label directions.



Be sure pesticides are secure during transportation.

Use the following checklist to make sure you are transporting your materials safely:

Inspect the vehicle and trailer:

— Remove sharp objects from the truck bed.
— Check lights, tires, mirrors, steering and brakes.

Put safety equipment and spill kit components in the vehicle:

— Soap and water for cleaning hands, plenty of fresh water for flushing eyes or skin.
— Protective clothing, boots and chemical-resistant gloves.
— Respirator for toxic fumes.
— Goggles/face shield to protect eyes.
— Shovel to build dirt dikes.
— Adsorbent material for small spills.

Make sure you have:

— Your pesticide certification card.
— A tarpaulin to protect containers in case of rain.
— Emergency telephone numbers.
— A first aid kit.

Never transport pesticides in the passenger compartment of any vehicle. Do not stack heavy pesticide containers on top of light ones. Remain alert when driving and handling pesticides. Drive with extreme caution and check with state regulations to determine if your pesticide load requires your vehicle to be labelled with a placard. Be familiar with pesticide label directions and follow them precisely.

These things should be readily available when transporting or working with pesticides.

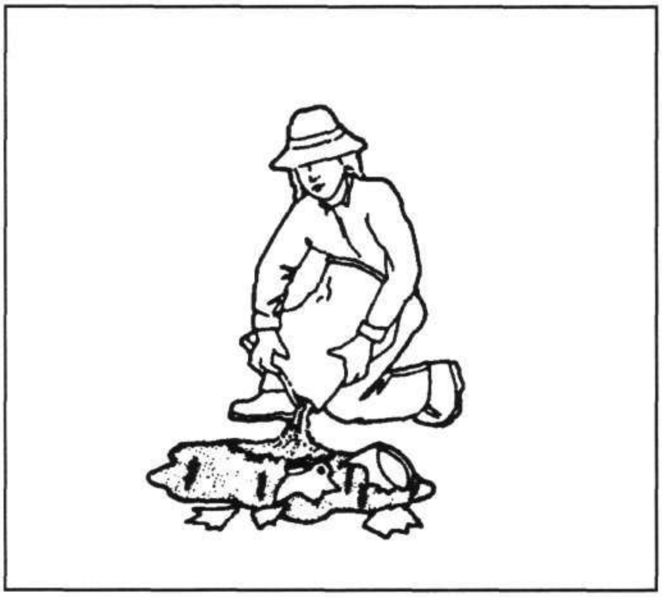
What to do if a spill occurs:

1) Secure the area — keep people at a safe distance.

2) Put on safety equipment to protect yourself from exposure.

3) If possible, stop the leak without endangering yourself or others. To stop a small spill on the ground, use adsorbent material and contain it with a dirt dike. Do not use water it will only spread the spill.

4) Notify the local fire department.



Use an adsorbent material to clean up liquid spills.

Maintaining and Washing Personal Protective Equipment

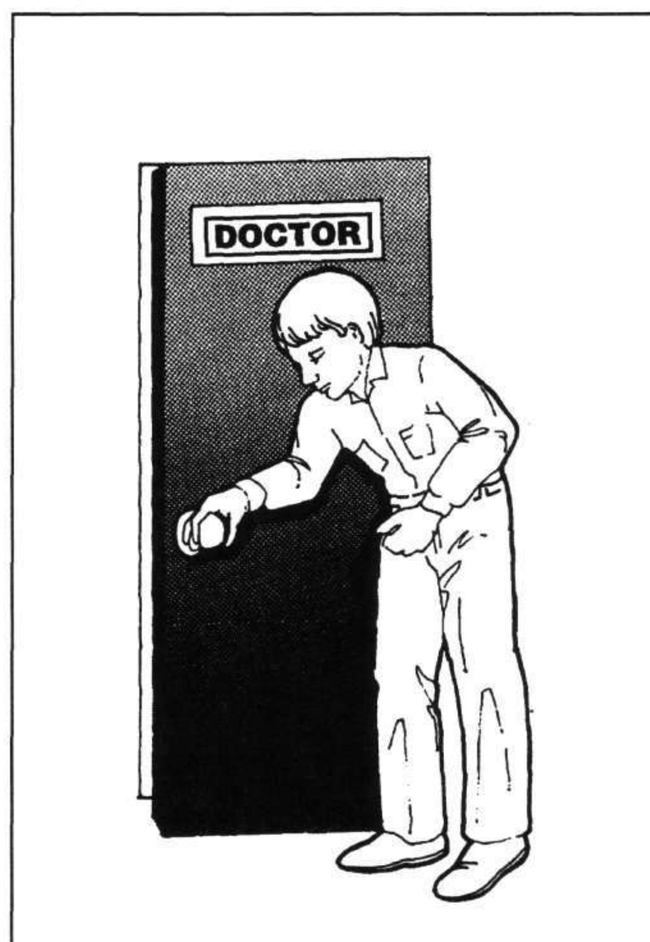
Protective clothing is useless, and may even be harmful, if not properly used and maintained. Check each garment for defects before each use.

Shower as soon as possible after using a pesticide and before changing into clean clothes. Be sure to use plenty of soap and water. Wash your hair thoroughly and scrub your fingernails.

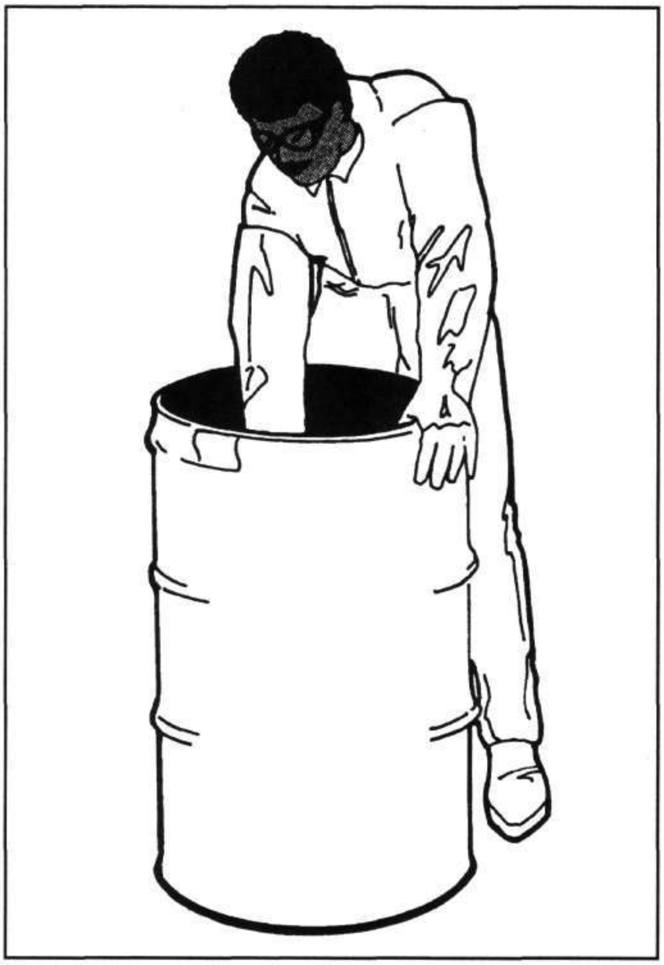
The best procedure for washing nonchemical-resistant items — such as cotton, cotton/polyester, denim, canvas and other absorbent materials and most chemical-resistant items is:

1. Wash clothing **daily** and **separately** from family wash.
2. **Prerinse, presoak** or **pretreat** with a stain remover.
3. Use **hot** water and the highest water level.
4. **Wash in a washing machine,** using a heavy-duty liquid detergent and use the longest wash cycle.
5. **Rinse twice** using two entire rinse cycles and warm water.
6. **Use two entire machine cycles** to wash items that are moderately to heavily contaminated.
7. **Run the washer through at least one additional entire cycle** without clothing, using detergent and hot water, to clean the machine after each batch of pesticide-contaminated items and before any other laundry is washed.
8. **Hang the items to dry, if possible.** It is best to let them hang for at least 24 hours in an area with plenty of fresh air. When the items are hung outdoors and exposed to clean air and sunlight, any remaining pesticide residues may evaporate or photodegrade (breakdown because of exposure to sunlight). You may wish to have two or more sets of equipment at a time so you can leave one set airing in a clean place while you are using the other set.

Even with the proper equipment and care, accidents happen. Always follow the first aid instructions on the label in case of exposure. If you feel dizzy or strange in any way, get to fresh air and rest. If you must go to a medical facility for treatment, ALWAYS TAKE A LABEL OR EMPTY CONTAINER WITH YOU.



When finishing an application, place all properly rinsed, empty containers securely (tied down, stabilized, out of reach of children, etc.) in the vehicle. Follow container and equipment rinsing procedures explained in the core manual "Pesticide Handling, Storage and Disposal" chapter. All equipment should be cleaned and washed before leaving the site.



Used, protective clothing should be placed in a clearly identifiable bag. Wash your hands with soap and water or other specialized hand cleanser that will neutralize any pesticide residue on the skin. Once the boat is empty and washed out, put it on the trailer, be sure your posted informational signs are securely in place, fill out your treatment report and go to the next site.

Record the events of the day after completing each scheduled job. Include all pesticide information as required by Regulation 636. Your records should include weather, water conditions such as temperature and wave activity, target species condition, abundance, size, life stage, persons encountered and any other notable events.

Record information about your applications and events of the day.

Chapter 2 – Pesticide Safety Review Questions

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

1. What pesticide information must an applicator understand to minimize risk, and where can this information be found?

2. What is the primary means of communication between pesticide manufacturers and pesticide users?

   a. Sales representatives.

   b. University researchers.

   c. Sales brochures.

   d. The product label.

3. List seven or more parts of a pesticide label.

4. What information is included in the ingredient statement?

   a. Active ingredients.

   b. Amount of inert ingredients.

   c. The percentage of each component.

   d. All of the above.

5. List the signal words and symbols used on pesticides labels.

6. What does a personal protective equipment statement tell a pesticide applicator?

7. Pesticides should not be used:
   a. At less than label rates.
   b. At longer intervals than stated on the label.
   c. At rates higher than directed by the label.
   d. None of the above.

8. What uses are **not** considered inconsistent with the label?

9. What is the equation for determining the hazard associated with a pesticide?

10. What is hazard, and what does it depend upon?

11. How does one choose personal protective equipment (PPE)?

12. What garments are required for minimum protection, and what pesticide signal words are associated with minimum protection?

13. When should an applicator wear a chemical-resistant apron?
   a. While mixing and loading pesticides.
   b. While cleaning pesticide equipment.
   c. When the label requires the applicator to wear one.
   d. All of the above.

14. What should be done if a spill occurs?

CHAPTER 3

INTEGRATED PEST MANAGEMENT

Michigan residents are fortunate to have and enjoy abundant, fresh, clean surface and groundwater. Natural lakes and ponds are plentiful, and artificial lakes and ponds continue to be designed and developed. Clean and attractive water systems can quickly become undesirable or even a liability when invaded by nuisance weeds or invertebrate pests. Several factors influence how and why a pest becomes established in an aquatic area. Thus, several management decisions must be made to recover the lost qualities of a body of water effectively and safely.

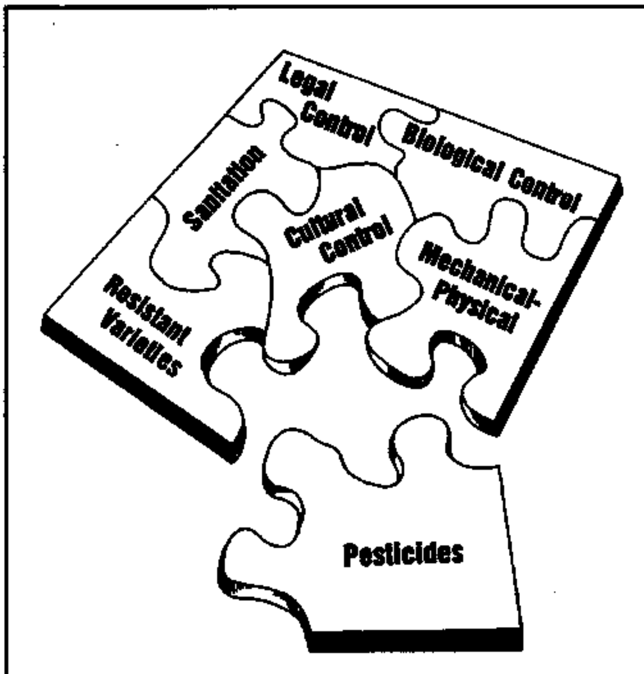
A system known as **integrated pest management (IPM)** is a useful way to effectively manage pests in complex biological systems using a variety of pest management tools. IPM is a logical sequence of events including gathering information, making decisions and taking action to control a pest. The goal of IPM is to reduce pest impacts to an acceptable level. Typical components of an IPM program are:

1. Site evaluation and detection.
2. Pest identification.
3. Economic, aesthetic and recreational significance.
4. Selection and use of management methods.
5. Evaluation of management methods used.

The core pesticide applicator manual (E-2195) discusses IPM in general pest management terms. This chapter will discuss IPM in aquatic environments.

IPM is the use of the most appropriate management tools and practices, selected from all available management tactics, to manage pests. The goal of IPM is to economically achieve a desirable aquatic environment with the least disruption to the water users and the environment. An IPM approach to pest management provides the applicator with pest management options that avoid sole reliance on one technique and its potential shortcomings.

IPM systems will vary from site to site. Changing water conditions, pests, available management techniques (natural and applied), weather conditions, and social and economic circumstances all contribute to variability. To have an effective pest management program, the aquatic pest manager must be able to recognize and understand what things affect the lake, pond or other water bodies they are managing. The following components are aspects of successful pest management programs.



Components of an IPM Program

1. Site Evaluation and Detection

An effective aquatic pest manager becomes familiar with each aquatic environment he/she manages. In an IPM program, monitoring is the process of information gathering and collection through observation of the site. Effective aquatic pest managers take a holistic approach to evaluating aquatic environments, drawing from the basic principles of geology, hydrology, biology and ecology. From this base of knowledge, the aquatic manager can identify various site characteristics, make decisions about water quality and assess potential causes of poor aquatic conditions.

When monitoring aquatic sites, it is vital to take note of many characteristics, including:

- Location of the body of water and water uses — e.g., irrigation, recreational uses.
- History of the water uses and previous management practices.
- Desired goals, objectives, attitudes and expectations of the water users.
- Water quality, fertility, pH, clarity, temperature, hardness.
- Inflowing and outflowing water routes, springs.
- Fish species present, their age, size and abundance, and ecosystem roles.
- Diversity of birds and animals, including bottom-dwelling organisms.
- Native vs. exotic aquatic vegetation — submerged, emergent, shoreline and wetland.
- Bottom characteristics such as depth, slope, sediment type and quantity.
- Appearance of water's edge, shoreline or banks.
- Surrounding development and activity — housing, agriculture, industry, location of wells, etc.— that can influence aquatic environments.

As you read this manual, you will notice how these site characteristics affect pest and non-pest organisms within an aquatic environment.

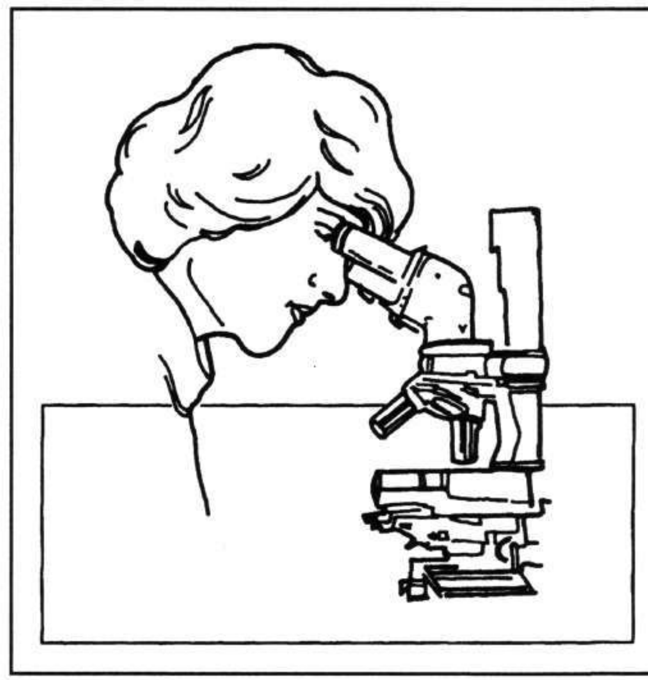
Monitoring should be done routinely throughout the year. This allows you to witness subtle changes in plant and animal development that occur on a yearly cycle. Routine monitoring occurs during scheduled site visits to detect pest populations. Record timely information about the pest and the site, such as:

- Water temperature, clarity and use.
- Pests' presence.
- Pests' development and density.
- Areas within the water body that are infested by the pest, noting the pests' desired habitat.
- Riparian (residents along the water) attitudes about various pest management strategies.

2. Pest Identification

Confirming the pest's identification, life cycle and population density and the pest's relationship to the aquatic environment is essential to an IPM program. Correct identification is necessary to select the most effective pest management strategies.

An organism should not be classified or treated as a pest until it is proven to be one. A species may be a pest in some situations and not in others. Many species look similar, and correct identification is necessary to avoid unnecessary pesticide applications. For example, the later chapters in this manual note that there are several species of leeches and lampreys. Most leeches and lampreys are beneficial, but look like undesirable species at certain life stages.



Accurate identification is critical to effective pest management.

The more you know about a pest and the factors that influence its behavior, the easier and more successful pest management becomes. When you identify a pest, you gain important biological information that influences management decisions. You can determine if controls are necessary and, if so, what tactics and tools should be used.

Knowing a pest's life cycle is essential. It allows you to time your treatment so it coincides with the pest's vulnerable life stage. A pest may be affected by your treatment only as an egg, a small plant, at flowering, as an adult, etc. Monitoring helps you pinpoint a pest's vulnerable stage in a particular body of water. The timing may be different from year to year and from one water body to the next.

Each water body should be monitored to determine pest management timing. For example, in a shallow lake, a plant or animal pest may be a week or more ahead in development than the same pest species in a deeper, colder lake.

Aquatic plants respond to water temperatures. Understanding these temperature responses allows the aquatic manager to predict plant emergence and developmental stages. Accurately timing herbicide applications enhances selectivity — removing the target pest without injuring nontarget species. Certain weed species grow earlier in the spring than many desirable plants. With this knowledge, the manager monitors the water body, anticipating the emergence of the weed pest. The herbicide application is made when it emerges so that nontarget (desirable) species are not influenced. This type of timing and selectivity can reduce competition from nuisance species so the growth of desired plants is enhanced.

3. Economic, Aesthetic and Recreational Significance

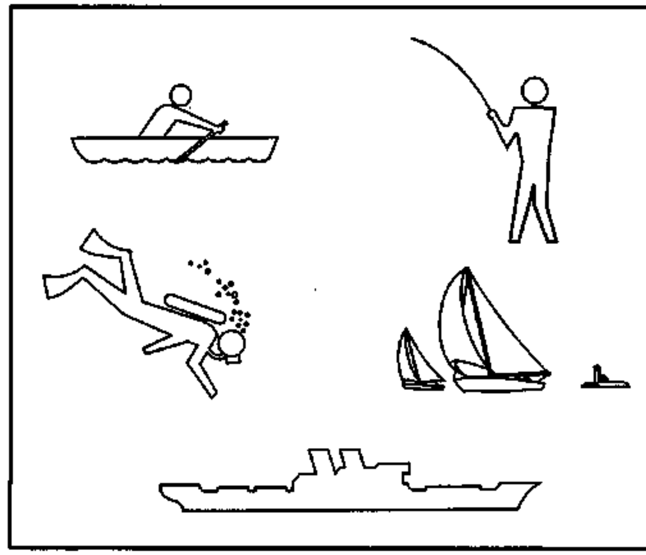
Control of pests should be considered only when valuable species are threatened by the invasion of nonnative organisms, when pests hinder recreational activities or other water usages, or when they detract from the aesthetics of the water body. These undesirable situations can influence the value of property adjacent to the water body as well as the quality of life of the people living there.

How and when to implement aquatic pest management tactics will vary by location. A selected pest management procedure must be economical and have minimal potential for harming people, nontarget species and the environment, yet, effectively reduce the nuisance.

Lakes and ponds with limited access or few shoreline residents or visitors may tolerate a higher density of weeds or less desirable fish species than other water bodies. For more intensively used water, the **pest management action threshold** — a level, such as a pest population, at which management actions will take place and below which action will not take place — is lower than in the more remote, less heavily used aquatic setting.

Pest management measures may be implemented when algae and/or plants reduce the aesthetic value of the water body. This aesthetic impairment causes perceived and real losses in property values that justify the cost of pest management procedures.

Certain waterways are used for business purposes. When pests impede navigation or hinder recreational pursuits — such as marina operations, sport fishing, scuba diving or shipping of freight — the cost of most pest management procedures is justified by continued or return business.



Excessive weed growth impedes many kinds of aquatic activities.

When aquatic pest infestations limit fishing, boating, swimming, water skiing and other recreational activities, riparians may choose to reduce pest levels. In each case, the choice to use a pest management procedure depends on the people affected by the pest, the cost of retaining or recovering the water quality they desire, and their willingness to accept the risk of potential personal and environmental injury.

Improved economics as it relates to aquatic business and property values, enhanced aesthetics and pursuit of recreational activities are the primary incentives that lead to a coordinated aquatic IPM program. Clearly identifying goals for each water body — i.e., desired water conditions after a pest management treatment — determining when a treatment is necessary and identifying the most opportune time to take action to achieve these goals are all components of an IPM program. These goals and decisions should be clearly stated, understood and acceptable to everyone involved: the riparians, visitors to the water body, the Michigan Department of Natural Resources and the aquatic pest manager.

4. Selection and Use of Management Methods

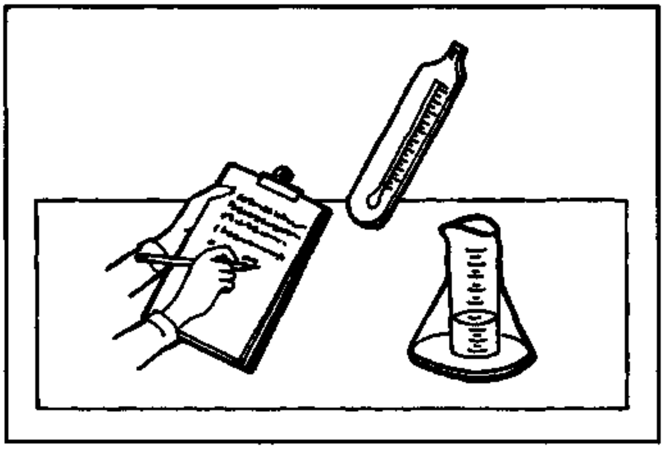
Once a pest problem is recognized, the biology and the habits of the pest understood, and the economic, aesthetic or recreational impacts identified, then the appropriate method or combination of methods can be selected to manage the pest. Management methods must be effective, practical, economical and environmentally sound. Proper method selection requires familiarity with all available management methods. Evaluate the benefits and risks of each management method applied to a given situation. Preventive, physical, mechanical, biological and chemical methods should be evaluated for short- and long-term effectiveness, applicability to the situation, level of pest control desired, environmental implications and cost. For example, when selecting a chemical tool, consider the toxicity of your choice and whether something less toxic is an effective option. Understanding what actions or events led to a pest problem may allow an aquatic pest manager to recommend a change in practices to correct or prevent a certain condition.

Following chapters discuss methods for managing vertebrates and invertebrates. The dominant pest the aquatic pest manager faces is weeds. Options for managing weed problems are discussed in the aquatic vegetation management chapter of this manual. Management options may include:

- Reducing nutrient inputs.
- Dredging and deepening shoreline areas.
- Harvesting weeds with mechanical equipment.
- Drawing down water levels in the winter.
- Using nontoxic dyes or benthic barriers, or aerating water bodies.
- Using aquatic pesticides.

5. Evaluation of Management Methods Used

Keeping records and evaluating your management strategies are extremely important. Thorough records can be referred to when you're making future decisions. Evaluate the efficacy of various management techniques and their performance under the wind, water and weather conditions present at the time they were used. Trying various methods allows you to determine the techniques that provide desired results for particular sites or conditions.



Effectiveness is likely to vary from site to site. Records help you recognize these variations and the conditions that may have caused them.

Evaluating pest management results may entail sampling pest populations before and after treatments. These records can be compared from year to year, allowing you to determine changes in pest pressures. An increase in pest pressure should cause you to reevaluate your management program and consider using other strategies.

The diversity of plant, animal and insect species should be monitored. Generally, good water quality supports a diverse group of species. The number of each type is low and an equilibrium exists. Poorer water quality frequently results in fewer species that may be at nuisance levels. Aquatic earthworms, for instance, are tolerant of poor water quality, so large populations may indicate poor conditions. Some water bodies with poor quality do support many species, but they tend to be less desirable types. As you manage various sites, your treatments may improve the aquatic environment or cause undesirable changes. Evaluating changes or stability in species diversity is a useful indicator of aquatic environmental quality. This information will help you understand the impact of your management activities.

Records of pesticide use by commercial applicators must be kept according to Regulation 636. Read the "Laws and Regulations" chapter in this manual for more details.

Chapter 3 – Integrated Pest Management Review Questions

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

1. The goal of integrated pest management is to reduce pest impacts completely. True or False?

2. Which is essential when using an IPM program?
   a. Confirming the pest's population density.
   b. Correct identification of the pest.
   c. Knowledge of the pest's life cycle.
   d. All of the above.

3. The process of information gathering and collection through observation of the site is ______________________.

4. List at least four site characteristics that are important to take note of when monitoring aquatic areas.
   1.
   2.
   3.
   4.

5. Although an organism may not be a proven pest, it should be treated if it looks similar to a harmful organism. True or False?

6. Why is knowing a pest's life cycle essential?
   a. It allows you to time your treatment to coincide with the pest's vulnerable life stage.
   b. You can determine if controls are necessary and what tactics and tools should be used.
   c. It helps you know what environment they will be in at a particular stage in their life.
   d. Both a and b.
   e. All of the above.

7. What do we call the level at which management actions will take place and below which action will not take place?
   a. Selectivity.
   b. Threshold.
   c. Minimum pesticide level.
   d. None of the above.

8. The dominant pest facing the aquatic pest manager is ______________________.

9. Which of these statements is not true?
   a. Good water quality supports a balanced diversity of species; the number of each type is high and an equilibrium exists.
   b. Management techniques are likely to vary from site to site.
   c. Poorer water quality frequently results in fewer species that may be at nuisance levels.
   d. The efficacy of various management techniques and their performance under the wind, water and weather conditions should be evaluated and recorded.

10. Which of the following is necessary to have an effective pest management program?
    a. Complete elimination of the pest.
    b. Repeated use of the same technique to destroy the pests.
    c. The aquatic pest manager must be able to recognize and understand what things affect the lake, pond or other water body he/she manages.
    d. The manager must do anything possible to destroy the pests.

11. Control of pests should be considered when:
    a. Any organism takes residence in the system.
    b. Valuable species are threatened by the invasion of nonnative organisms.
    c. Pests hinder recreational activities or water usages or detract from the aesthetics of the body of water.
    d. Both a and b.
    e. Both b and c.

CHAPTER 4

CONDITIONS FOR AQUATIC PLANT GROWTH

Aquatic pesticide applicators manage aquatic vegetation more than any other organism or group of organisms. To manage weeds effectively, the applicator must understand the conditions promoting weed growth. Sunlight and nutrients are two major factors that regulate plant growth. In aquatic habitats, the depth of **light penetration** usually determines the maximum depth at which underwater plants will grow. The amount of available plant **nutrients** roughly determines the amount of vegetation that can be produced. Other important growth factors include **temperature** and, for rooted plants, a **stable substrate** and **protection from wave action.** The potential for a body of water to develop an aquatic weed problem can be estimated by evaluating the availability of each of these growth-regulating factors. These factors characterize shallow water, so many aquatic weed problems are found in shallow areas.

Light

Aquatic plants do not grow in water that is so turbid (murky, muddy) or deep that all light is blocked. They can, however, grow at very low light intensities, even less than one percent of the surface light on a midsummer day.

The **photic zone** is the portion of a body of water in which enough light can penetrate to support aquatic plant growth. The bottom of the photic zone is defined as the depth at which the light intensity is equivalent to one percent of full sunlight. In silty ponds, the photic zone may be only a few inches; in extremely clear bodies of water, the photic zone can extend to a depth of 30 feet or more. The photic zone for most southern Michigan lakes is 10 to 12 feet deep. The shallower the water body, the more likely it is that the photic zone will extend to the bottom sediment, where rooted plants can grow.

Water clarity is also influenced by water *hardness.* Water hardness is a measure of dissolved calcium, magnesium, iron and strontium. Ions of these elements can bind with suspended particles such as clay and organic matter and cause them to precipitate (settle). Precipitation removes particles that would normally reduce light penetration. *Soft,* acid waters with low calcium and magnesium concentrations are often characterized by suspended organic substances that prevent good light penetration.

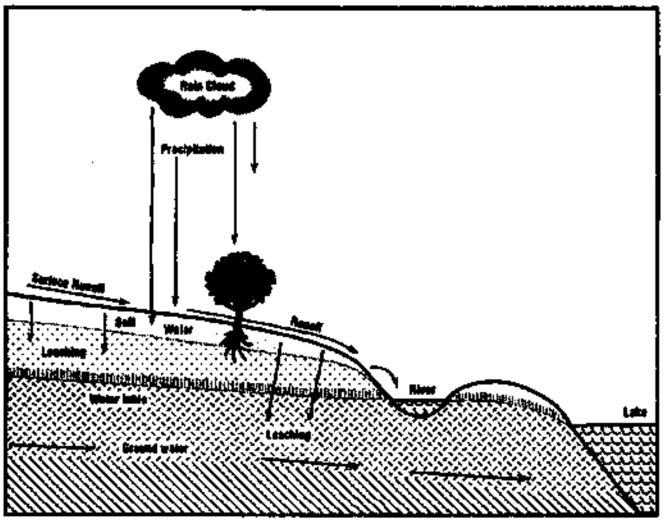
Hardness is usually expressed as parts per million (ppm) of calcium carbonate. Hard waters (hardness values greater than 60 to 75 ppm of $CaCO_3$) tend to be clearer and therefore weedier than soft waters.

Nutrients

Introduction of unnaturally large amounts of nutrients and sediment into water bodies is a primary factor hastening lake deterioration. Human activities are the primary contributor to lake deterioration by these means. The major nutrient of concern is phosphorus (P), found in most fertilizers (P_2O_5) and organic wastes.

Plants such as **phytoplankton** (free-floating algae), filamentous algae and free-floating flowering plants obtain their nutrients directly from the water. Rooted plants obtain most of their nutrients from the sediments by root uptake. Therefore, both water and sediment nutrient content are important water body characteristics. It is possible to have dense stands of submersed weeds in clear, clean waters that do not have high **water** nutrient content, but do have high **sediment** nutrition.

Nutrients can enter aquatic systems from precipitation (rain), streams, springs, groundwater, and **runoff** (water carrying with it other liquid compounds, water moving soil with contaminants bound to it, or both) from urban and rural areas. The area where these water sources are generated and/or move through is called a **watershed.** In general, the larger the watershed (area draining into a body of water), the greater the amount of nutrients being deposited in a water body with potential to produce more aquatic plants.



Nutrients generated by urban, rural and natural activities enter aquatic areas through many processes.

Runoff is a major contributor to the nutrient enrichment, or "nutrient loading" of surface waters. It is not unusual to see the most prolific weed and algae growths occurring in shallow shoreline areas where sediment loading is greatest. Nutrient contributors from urban watersheds include sewage effluent (discharge), storm sewer drainage and septic field seepage. Agricultural sources include runoff from fertilized fields, feedlots and nearby pastures. These supplemental nutrients can be used by algae and aquatic plants and encourage excessive plant growth.

As algae and plants die, they fall to the lake bottom and decompose. This decomposed plant matter contributes to the nutrient enrichment of the bottom sediments **(hydrosoil)** and formation of organic substrates called muck. Also, large amounts of decomposing plants can lower the **dissolved oxygen** (D.O.) level in a body of water. Radically lowering the D.O. level can cause fish kills by suffocation. Be aware that the D.O. level may drop dramatically after mechanically cutting aquatic weeds without harvesting, herbicide treatment or seasonal dieback of the aquatic plants.

When aquatic plants are so productive that they begin inhibiting human activities, methods of aquatic weed management are usually considered. Appropriate weed management techniques vary with the weed species, selectivity, cost and the goals of the lake management plan.

Water Body Characteristic	**Rooted Plant Production**	
	LOW	**HIGH**
Average depth	> 15 feet	< 15 feet
Water clarity/light penetration (Secchi disk)	< 3 feet	> 3 feet
Sediments	Sand or highly organic (loose, unconsolidated ooze)	Moderately organic, muck, stable
Dominant fish species	Trout, salmon	Bass, bluegill, pike

Table 1. Selected water body characteristics related to the production of rooted plants.

Water Quality Parameters	**Phytoplankton Production**	
	LOW	**HIGH**
Dissolved solids	Low	High
Total phosphorus	0 - 0.01 mg/L	> 0.01 mg/L
Dissolved 0_2	Stable	Highly variable
Dominant fish species	Trout, salmon	Bass, bluegill, pike

Table 2. Selected water quality parameters related to the production of phytoplankton.

Temperature

Most aquatic plants grow best in the warm waters of late spring and early summer and reach maximum size in midsummer. Shallow water warms up faster than deeper water and usually exhibits the first visible growth of aquatic plants. Shallow waters provide aquatic plants with long growing periods, even in the northern states where the growing season is normally short.

Temperature is an important factor in determining the life cycle and geographic distribution of aquatic plants. In temperate zones, the onset of cold temperatures and/or the change in photoperiod in the fall causes most aquatic plants to die back to the sediments. Only a few underwater plant types living in deep water can survive the winter under an ice cover as leafy plants. These leafy, winter-surviving plants lose little in **biomass** (volume of living plant material) during these cold periods. Such plants include large-leaf pondweed, Eurasian watermilfoil and elodea. Most aquatic plants emerge from the sediment in the spring from vegetative structures such as tubers (overwintering root structures), turions (overwintering structures made from leaf adaptations), seeds or root crowns.

It is crucial to understand aquatic plant responses to temperature changes so you can predict and identify life stages susceptible to your management technique. With this information, you can target management treatments to the point in the pest's life when it is most easily controlled (vulnerable). For example, curly-leaf pondweed begins to grow soon after the ice melts. In Michigan, it normally completes its life cycle and collapses before July 4th. Optimum control for curly-leaf pondweed is achieved when the plant is treated after emergence but prior to the onset of turion formation, which occurs in late April to early May.

Substrate

A stable **substrate** (the base on which an organism lives) is required for the attachment of rooted aquatic plants. Sand tends to shift, so it is a poor substrate in flowing waters or along shorelines exposed to strong wind and wave action. In protected areas, sand, as well as silt and clay, interspersed with some organic matter provides an excellent rooting medium for most aquatic plants. Rock and large gravel substrates do not promote the growth of rooted plants because they are nutrient poor.

Runoff and erosion of terrestrial (land) sediments may cause a buildup of sediments along shorelines and at the mouths of inflowing streams.

Shallow areas with gradually sloping bottoms are also prime locations for weed infestations. In contrast, deep water bodies and those with steep sides provide few sites for plant attachment. These characteristics are important to understand when designing and creating ponds and lakes. Considering pest habitat and their management during the design and development stages allows for the incorporation of features that discourage pest invasion.

Chapter 4 – Conditions for Aquatic Plant Growth Review Questions

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

1. Which is not an important factor for aquatic plant growth?
   a. Temperature.
   b. A stable substrate.
   c. Sunlight and nutrients.
   d. Large amounts of wave action.

2. The portion of a body of water in which enough light can penetrate to support aquatic plant growth is the________________________.

3. The bottom of the photic zone is defined as:
   a. 30 feet beneath the surface.
   b. The depth at which the light intensity is equivalent to one percent of full sunlight.
   c. The depth at which the light intensity is equivalent to ten percent of full sunlight.
   d. Only a few inches beneath the surface.

4. ________________________water is often characterized by low calcium and magnesium concentrations and suspended organic substances that prevent good light penetration.

5. It is possible to have dense stands of submersed weeds in clear, clean waters that have low water nutrient content, yet have high sediment nutrition. True or False?

6. The larger the watershed (area draining into a body of water):
   a. The greater the amount of nutrients being deposited in a water body with the potential of producing aquatic plants.
   b. The more the amount of nutrients are dispersed, reducing the aquatic plants.
   c. The greater the water hardness, reducing the potential of producing more aquatic plants.
   d. Both b and c.

7. Large amounts of decomposing plants can ________________ the dissolved oxygen level in a body of water.
   a. Raise.
   b. Lower.
   c. Have no effect on.
   d. Stabilize.

8. Which is not a dominant fish species if phytoplankton production is high?
   a. Pike.
   b. Bass.
   c. Bluegill.
   d. Trout.

9. Temperature is an important factor in determining what characteristics of aquatic plants?

10. Why is it necessary to understand aquatic plant responses to temperature changes?

11. Which of these statements is false?
    a. Sand is a poor substrate in flowing waters or along shorelines.
    b. Silt and clay are poor substrates in protected areas because they are nutrient poor.
    c. Rock and large gravel substrates do not promote rooted plant growth.
    d. Shallow areas with gradually sloping bottoms are prime locations for weed infestations.

CHAPTER 5

AQUATIC PLANT IDENTIFICATION AND MANAGEMENT

One of the most important steps in aquatic plant management is the correct identification of plant species. A taxonomic key or plant outline can be very helpful to aquatic pesticide applicators.

The following discussion includes some of the common nuisance aquatic plants and algae found in Michigan, their identification and suggested strategies for successful management. Some non-weedy plant species commonly found in aquatic areas are included.

Algae

Algae are generally classified as being either *planktonic, filamentous (attached)* or *erect.* All types of algae obtain energy from sunlight. Algae are simple plants without true roots, leaves or flowers. They reproduce by cell division, plant fragmentation or spores.

Planktonic algae are individual algae cells that are suspended in the water or form a film on the surface. Planktonic algae are responsible for low water clarity and can also cause allergic and/or toxic reactions in sensitive people. The most common group of nuisance planktonic algae is the blue-green algae. These species may turn the water a deep blue-green color. The blue-green algae can form green or dark green surface scum. They may accumulate on the downwind sides of lakes, forming unsightly gelatinous masses on shorelines.

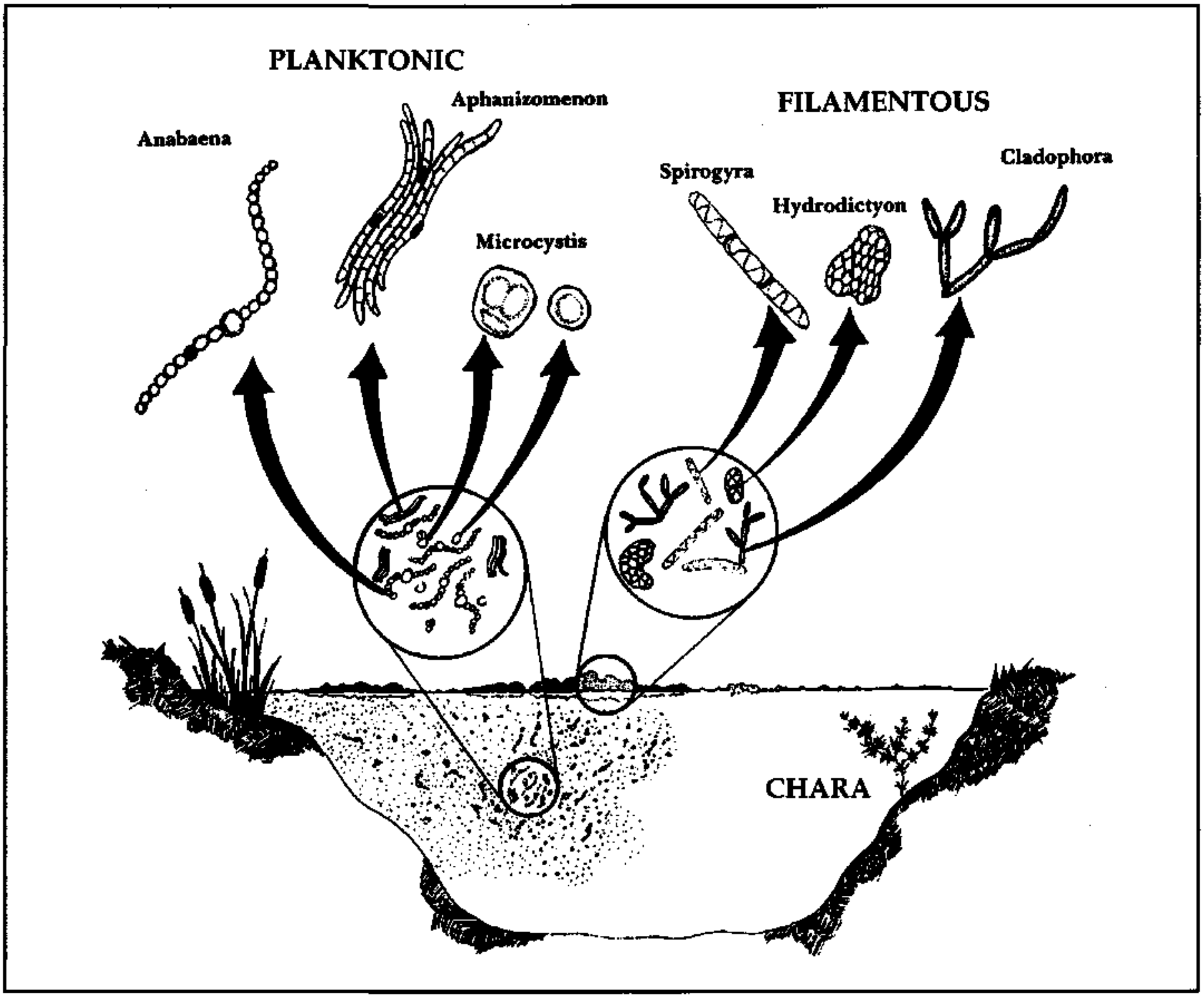
The blue-green algae are also noted for creating taste and odor problems in drinking water supplies where they accumulate. Some species are toxic and have been responsible for livestock illness and death. Natural die-off may cause summer-kill of fish due to oxygen depletion.

Many of the lakes and reservoirs plagued by nuisance planktonic algae are also characterized by fertile hydrosoils. Reducing the planktonic algae may then enhance production of rooted macrophytes by improving light penetration to the fertile hydrosoils. Therefore, anyone planning control strategies for planktonic algae should consider the potential for increased production of rooted macrophytes. This possibility should not necessarily be thought of as something negative — macrophytes can be useful and are easier to manage, if necessary.

Several **filamentous algae** genera have become significant nuisances in northern lakes. Filamentous algae can be split into two groups depending on growth habit: attached and planktonic (free-floating). Both types can be persistent and difficult to manage. The attached algae are found on docks, seawalls, boats and other hard surfaces. The texture varies from slimy to coarse, resembling wet cotton or hair.

Filamentous algae often become a nuisance on hydrosoils where nuisance rooted macrophytes have been indiscriminately removed. They also become a significant nuisance in the presence of macrophytes when the concentration of nutrients in the water column is high. Reducing nutrient loading may help to control nuisance filamentous alage if they are not growing in close association with nutrient-rich sediment.

The planktonic-type filamentous algae may form mats on the sediments, continually increasing in size and layers. As new layers grow on top of old layers, the algae mat becomes increasingly dense and the lower layers become shaded and die. Gases are produced as the dead algae decompose. As these gases combine with those normally released from bottom sediments, they are trapped below the algae mat. These gases can actually buoy the mats upward to the water's surface. These surface mats of algae are unsightly, trap debris, and are commonly referred to as "pond scum."



Algae habitats.

The **erect algae** *(Chara and Nitella)* resemble vascular plants. Erect algae grow from the sediment. Although they do not have roots, they do have hold-fast structures that anchor them to the bottom. Erect algae are considered valuable in maintaining water quality. They cover the sediments and absorb nutrients that are released. This aids in preventing the establishment of the other nuisance algae groups and other undesirable plant species.

Control of the various algae groups can be achieved by several similar techniques, though application rates and methods will vary. One approach is to broadcast an algaecide over the entire water and algae surface. Large mats of algae should be broken up with a boat propeller or high-pressure stream of water to maximize the treatment effectiveness. Directly spraying the floating mats and attached filaments will give the best results.

Control of erect algae is not usually recommended. In cases where control is desired, a granular algaecide is recommended because the pellets sink to the bottom and maintain contact with the algae. Chara can be difficult to control, particularly in hard water. Two or more treatments with contact herbicides may be necessary, and best results are obtained when the plants are young and uncalcified.

Take care when using copper-based algaecides. Certain doses (even very low doses) of copper are toxic to fish and aquatic organisms, especially to cold-water fish in soft water. Few lakes in Michigan have soft water (less than 50 ppm calcium carbonate).

Aquatic Flowering Plants

Aquatic plants can be described according to their growth habits as follows:

Submersed plants. Plants grow completely below the water surface and depend on the surrounding water for support of the plant body.

Emersed or emergent plants. Plants are rooted in the sediments, extend above the water surface and are self-supporting.

Free-floating plants. Plants are not attached to the sediments and float on the water surface or just below it. Most have roots that extend into the water for nutrient uptake.

Rooted floating plants. Plants are attached to the sediment and have leaves that float on the water surface. These plants may or may not be self supporting.

A great percentage of aquatic weed control measures implemented in Michigan are for the control of **exotic species** — plants native to other regions, countries or continents.

Many aquatic exotic plant species are capable of **displacing** (choking out — outcompeting) native and beneficial plants. Some exotic plants — Eurasian watermilfoil and curly-leaf pondweed in particular — form dense mats of near-surface vegetation and cover expansive areas. These mats are nearly impenetrable by watercraft. They not only make fishing, boating and swimming difficult, but may also adversely affect the chemistry of underlying waters, degrading fishery and fish-food organism habitats.

In contrast, many of our native aquatic plants exhibit a more open growth habit with patchy distribution. This type of plant "architecture" is more favorable for other aquatic organism needs. See pages 73-76 for identification of aquatic plants commonly found in Michigan.

Some plants that have been native to the southern United States are moving northward in distribution and becoming nuisances. These include the rooted macrophytes fanwort (*Cabomba caroliniana* A. Gray), southern naiad (*Najas guadalupensis*) and the filamentous *Pithophora* spp. algae. Our region's native plants usually keep themselves in check and do not grow to nuisance proportions.

Native plants fulfill necessary and beneficial roles in the aquatic ecosystem. They serve as food, habitat or shelter for other aquatic organisms. They serve as stabilizing features for the substrate, and they filter storm and runoff water as it moves through the aquatic area. Identifying both native and exotic plants allows you to anticipate the changes in aquatic environments due to exotic plant invasion or your management practices.

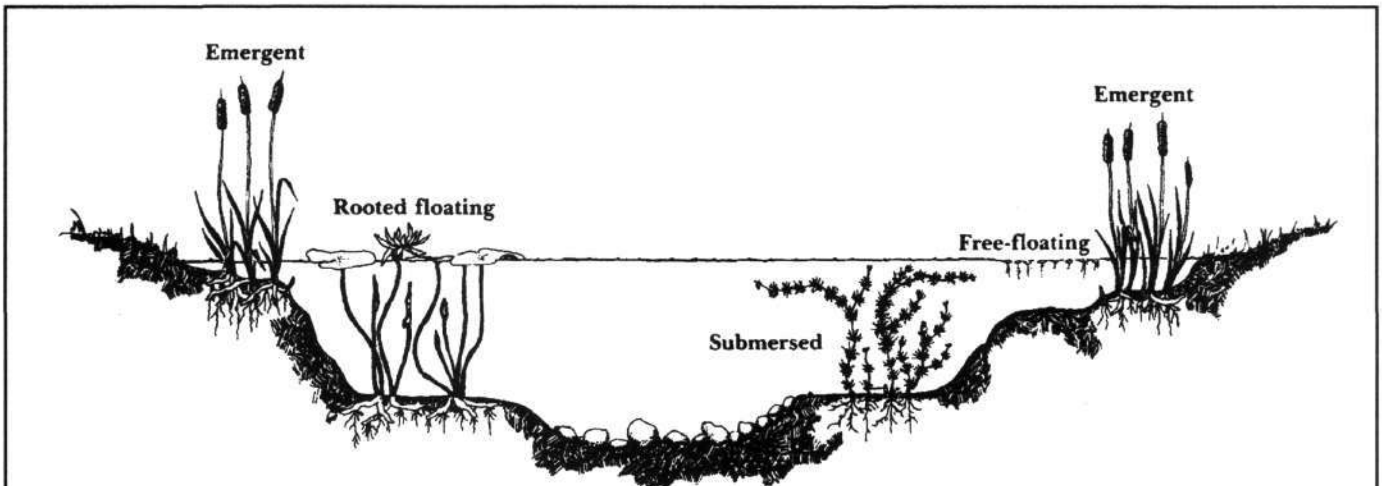
As an aquatic pest manager, strive to promote the continued existence of beneficial plants and minimize the production of weed species.

Conditions will vary from site to site, even on the same lake. Management tactics may not be effective under all treatment conditions. Be familiar with the techniques and products you are using and how they may react with and change the conditions and plant diversity at the treatment site.

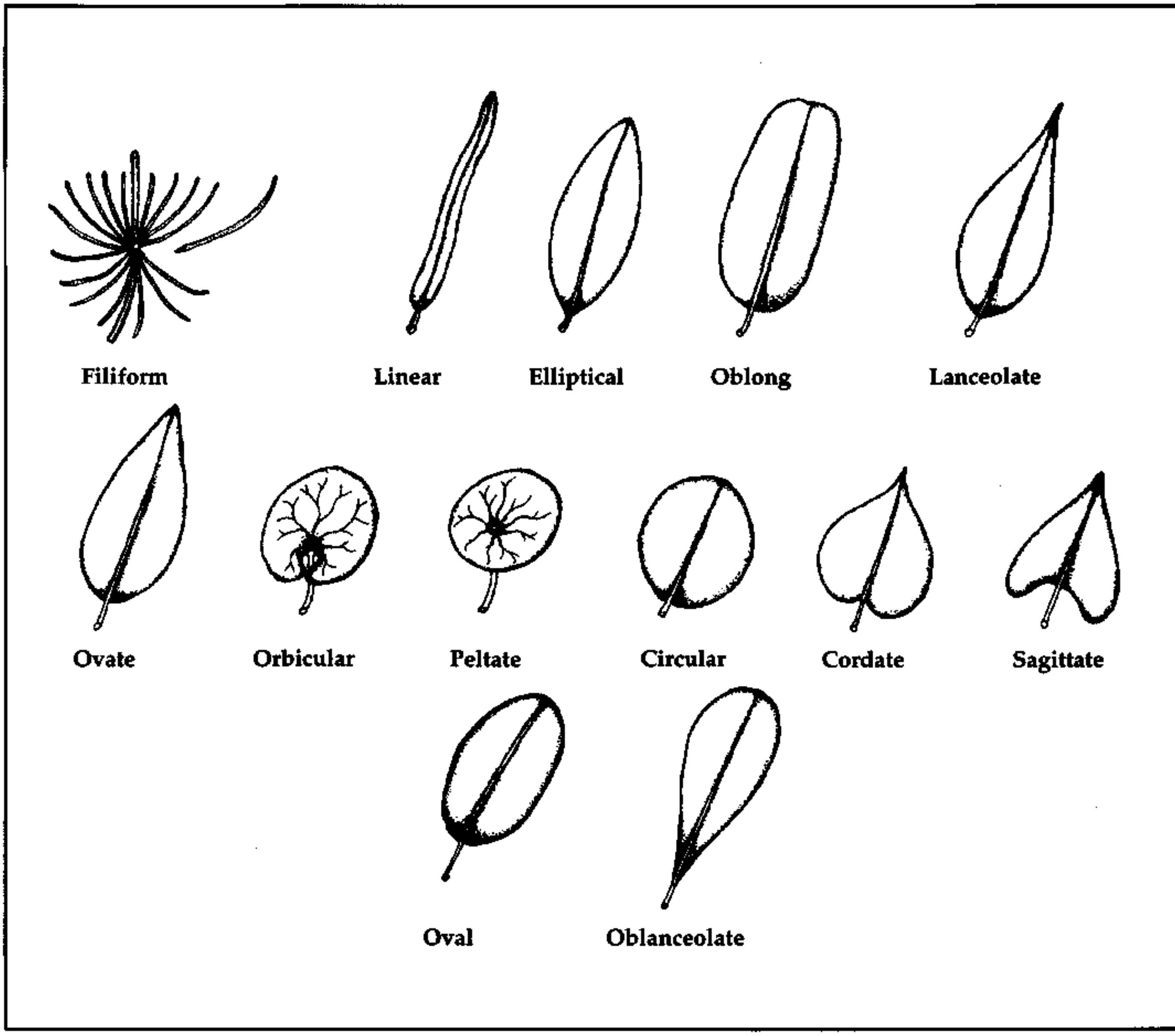
Submersed Plants

Watermilfoils

The watermilfoil species are members of the genus *Myriophyllum.* This group is composed of plants that grow submerged, grow at the surface and may have small flower stalks that extend above the water surface. Most watermilfoils are **native** plants requiring minimal management because they are rarely present in nuisance proportions. The watermilfoils reproduce mainly by **fragmentation** (plant pieces break off the parent



Four groups of aquatic flowering plants.

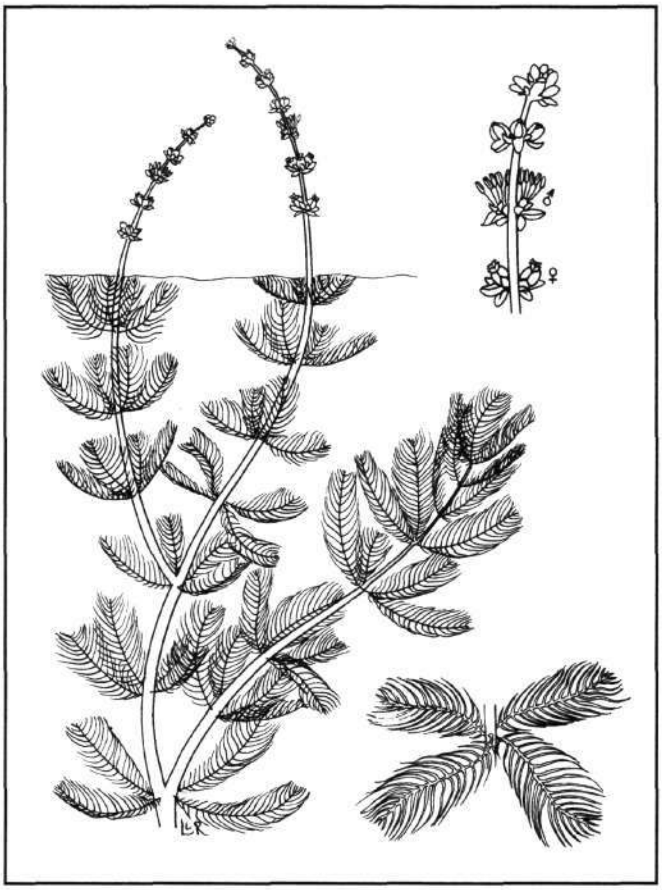


Leaf forms useful in identifying aquatic plants.

plant, develop new roots and become reestablished) and **stolons** (lateral stems). Reproduction by seed is rare for watermilfoils in Michigan.

The major watermilfoil of concern in the United States is the exotic Eurasian watermilfoil (*M. spicatum*). Eurasian watermilfoil was introduced to the United States in the 1940s. This species is opportunistic — Eurasian watermilfoil is adaptable to many growing conditions and quickly moves into areas that have been disturbed or changed. Because of this adaptability and their rapid growth rate, they can become established more quickly than other species. They easily grow to nuisance proportions in shallow and relatively deep water. Eurasian watermilfoil is of limited value to wildlife or fisheries because of its undesirably dense growth habit. Eurasian watermilfoil frequently displaces (chokes out) native plants.

Eurasian watermilfoil is susceptible to some systemic herbicides. Certain systemic aquatic herbicides can be used as **selective herbicides** to selectively remove Eurasian watermilfoil. Selective herbicides are effective only against certain species and are able to control unwanted plants (target plants) without serious injury to desirable species. Because Eurasian watermilfoil grows faster than most native species, the consistent use of **contact herbicides** (kills only tissue the herbicide touches, allowing regrowth from the roots) favors the continued reestablishment of this plant. Harvesting is **not** recommended for managing Eurasian watermilfoil because this results in its spread by fragmentation. Long-term harvesting, like the consistent use of contact herbicides, encourages Eurasian watermilfoil's displacement of native or more desirable plant species.



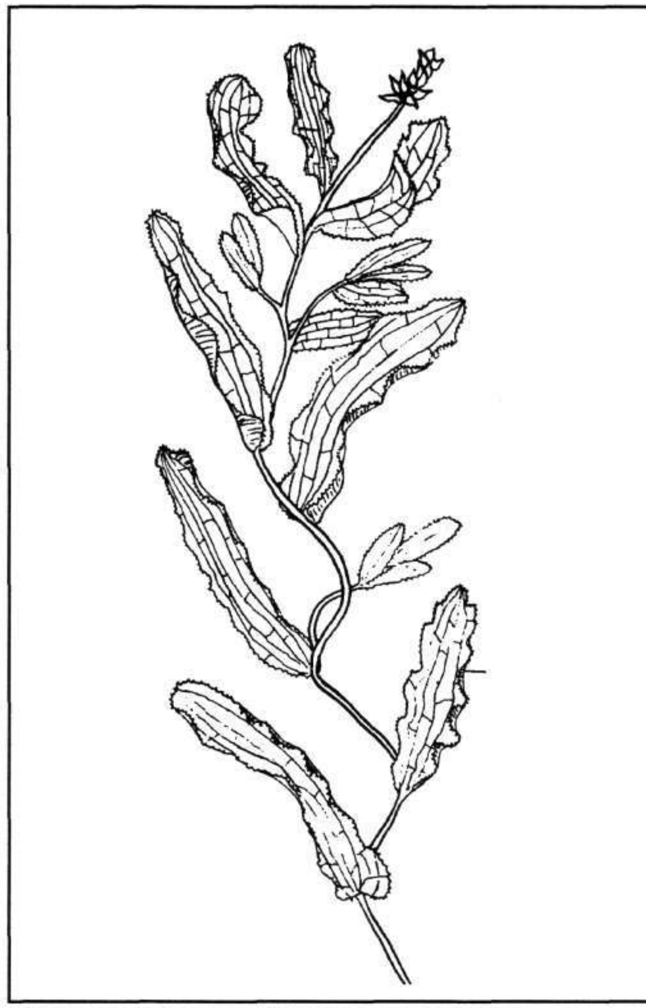
Eurasian Watermilfoil *(Myriophyllum spicatum)*

Pondweeds

The pondweeds are a very diverse group of aquatic plants. Identification of pondweed species can be difficult because structural differences among species are often small. Also, environmental factors often influence the growth form of a species, and hybridization between species is common. The growth form of a species may be related to current velocity, depth, clarity, temperature of water, time of year, nutrients, bottom type, etc.

Most pondweeds are beneficial native species that provide excellent habitat and food for fish, aquatic invertebrates and migrating waterfowl. One species, curly-leaf pondweed *(Potamogeton crispus)*, is an exception. Like Eurasian watermilfoil, this species is an exotic. It was brought to North America in the mid-19th century. Curly-leaf pondweed has since spread throughout the continent and become a pest in many locations.

Curly-leaf pondweed gets its name from its wavy leaf margins. This species can grow up to 6 feet and may spread by re-rooting of plant fragments. Curly-leaf pondweed emerges early in the spring. It flowers and sets seed in the late spring and early summer. In Michigan dieback occcurs, typically by the first week of July. After curly-leaf pondweed dieback occurs, it usually remains unnoticed until the following spring although it has been known to reappear due to regrowth of juvenile plants in late summer to early fall. Apparently these small plants are capable of overwintering below ice cover.



Curly-Leaf Pondweed *(Potamogeton crispus)*

Curly-leaf pondweed reproduces primarily by rhizomes and dormant leaf structures called turions. These turions can lie dormant in the substrate for several years, sprouting only when conditions are right. These dormant structures are not affected by herbicides.

Curly-leaf pondweed can be a serious nuisance during the early part of the summer when recreational activities are at a peak. Early control of this species is recommended so that the plant is not allowed to grow to large proportions and cause problems when dieback occurs in July. If large amounts of plant material die and decompose when water temperatures are high, the potential for oxygen stress (radically decreased dissolved oxygen [D.O.] levels) on the water body and its aquatic organisms is great. Many organisms can suffocate when the D.O. levels drop.

Broad-Leaved Pondweeds: (A) Richardson Pondweed *(Potamogeton richardsonii)* and (B) Floating-Leaf Pondweed *(Potamogeton natans)*

Narrow-Leaved Pondweeds: (A) Leafy Pondweed (*Potamogeton foliosus)* and (B) Flat-Stemmed Pondweed *(Potamogeton zosteriformis)*

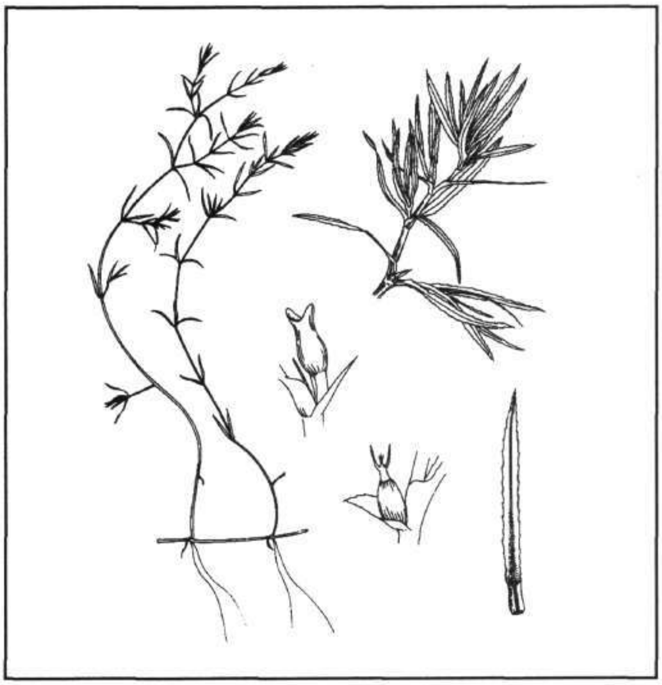
The other pondweeds can be classified as either narrow-leaved pondweeds, which have thread or ribbon-like leaves, or broad-leaved pondweeds, which have leaves usually wider than 1 cm (about a half inch). Members of these two general classifications can be used for food, cover, and shelter by wildlife and fish. Pondweeds are among the most important waterfowl foods in the United States.

Pest species of pondweeds can be controlled in a variety of ways. Applying certain herbicides early in the season can selectively remove curly-leaf pondweed without affecting either group of beneficial pondweeds which sprout later in the season. Both application timing and herbicide formulation allow certain herbicides to be used as selective controls of unwanted plants while avoiding serious injury to desirable plants.

The broad-leaved pondweeds are hardier than curly- or thin-leaved pondweeds and may require a combination of herbicides for control. Always consult the product label for mixing instructions and limitations. Most pondweeds can be mechanically harvested.

Naiads

The naiads (*Najas* spp.) are sometimes desirable and at other times considered a serious nuisance. They are desirable when found as low-growing lake bottom covers and are valuable to wildlife and fish. Naiads often grow in thick clumps, and they can be short, lake bottom dwellers or grow to heights that will reach the surface. When they grow to the surface and create impenetrable masses of vegetation, they become a nuisance.



Southern Naiad *(Najas guadalupensis)*

The naiads differ from other aquatic pest species in that they are **annuals** (complete their life cycle in one year) that overwinter as seed. Most other submersed aquatic species overwinter in a vegetative condition or produce special overwintering structures. The naiads are adapted to fluctuating water levels, possibly because of the seeds' hardiness. As a result, naiads often become serious nuisances in shallow areas managed by repeated drawdowns.

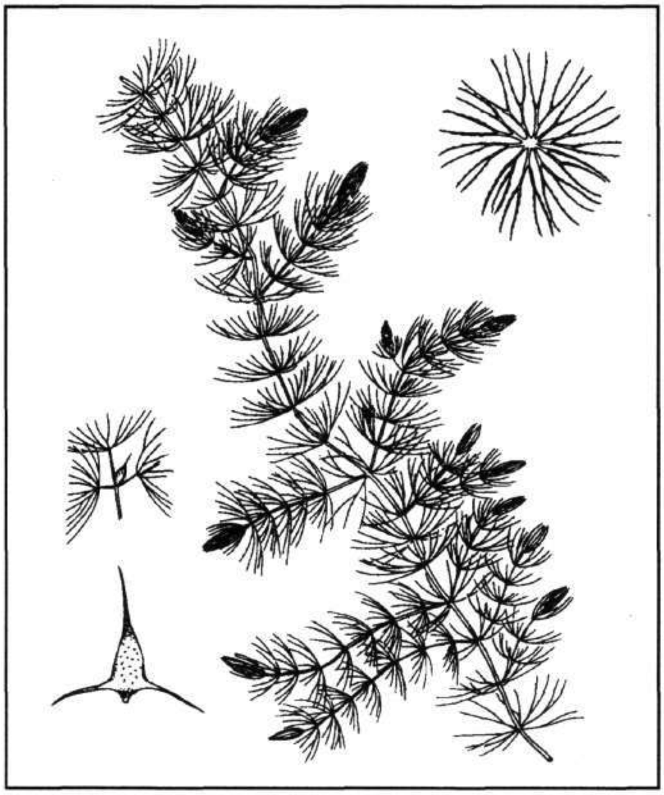
Naiads can reproduce from fragments as well as by seeds. If control is necessary, harvesting is not usually an effective option because these plants grow low to the ground and fragment easily.

Other Submersed Native Plant Species

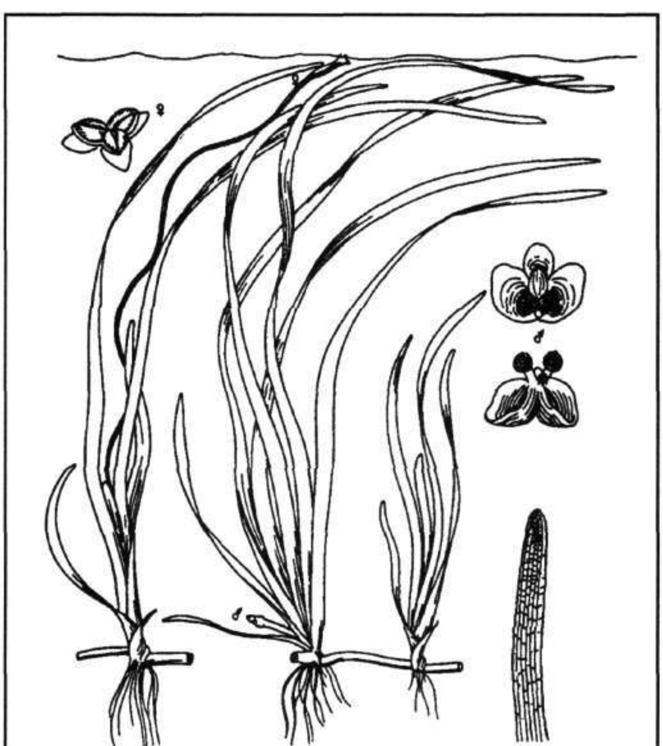
Most other native submersed aquatic plant species require little management. It is important to consider these non-pest plants in the overall lake management goals and recognize that some plants provide desirable features. Therefore, plan for areas that may serve as plant preserves.

Species diversity should be maintained by protecting the most desirable species from exotic plant invasions. Certain groups of plants benefit the lake by forming unobtrusive and valuable bottom covers that prevent wind-induced currents from suspending bottom sediments in the water body. It is also vital to recognize the food, shelter and habitat value that many plants provide for fish, waterfowl and other aquatic organisms. If a group of plants becomes a nuisance, they must be managed cautiously and with consideration for their many positive qualities.

Coontail *(Ceratophyllum demursum),* found in relatively quiet and deep water, is usually less than 3 feet long. It has clusters of finely forked leaves that appear bushy (like a raccoon's tail) at or near the ends of the stems. Leaves have small teeth along one side and are sometimes stiff with a coating of lime. Coontail harbors significant amounts of food for fish and waterfowl because its many fine branches are available for colonization by small aquatic animals. Coontail breaks into fragments easily and spreads in this manner. Harvesting may be effective in the short run, but, because of fragmentation, it is usually not recommended. Winter drawdowns may also increase coontail populations.



Coontail ***(Ceratophyllum demersum)***



Eelgrass ***(Valisneria americana)***

Wild celery or **tape (eel) grass** *(Valisneria americana)* is a hardy plant with long, limp, ribbon-like leaves all arising from the base of the plant. In summer, plants may have small pods on the ends of long stalks that originate at their base. The leaves and underground tubers of wild celery are preferred food for waterfowl such as mallards, canvasbacks and goldeneyes. Because it is an excellent wildlife food, people plant it to attract waterfowl. Excessive growth during July and

August in shallow water may present a problem. Try hand pulling, raking or screening the bottom if you must control or thin problem areas. Herbicide treatments are not recommended in areas where fish may be trapped — herbicide application rates required for control may harm the fish.

Elodea or **waterweed** *(Elodea canadensis)* is rarely a nuisance. Elodea provides cover for bluegills and perch and supports insects valuable as fish food. It has slender stems up to 7 to 9 feet long with three leaves in clusters around the stems. It grows completely below the water surface. Leaves are bunched in whorls of three toward the ends of the stems where new growth occurs. Older leaves usually senesce (decline, fade) and break off the lower stems. Elodea grows best in soft sediments and cool water. Elodea may rapidly colonize an area and then decline in abundance within 5 to 7 years. If necessary, it can be managed with certain aquatic herbicides or harvested. If you're treating it with chemicals, wait until the plants have matured (early or midsummer). Try physical removal to control problem areas. Hand pulling, raking, dragging or screening the bottom are effective control methods if broken pieces are removed from the water to prevent new plants from regenerating from fragments.

Elodea *(Elodea canadensis)*

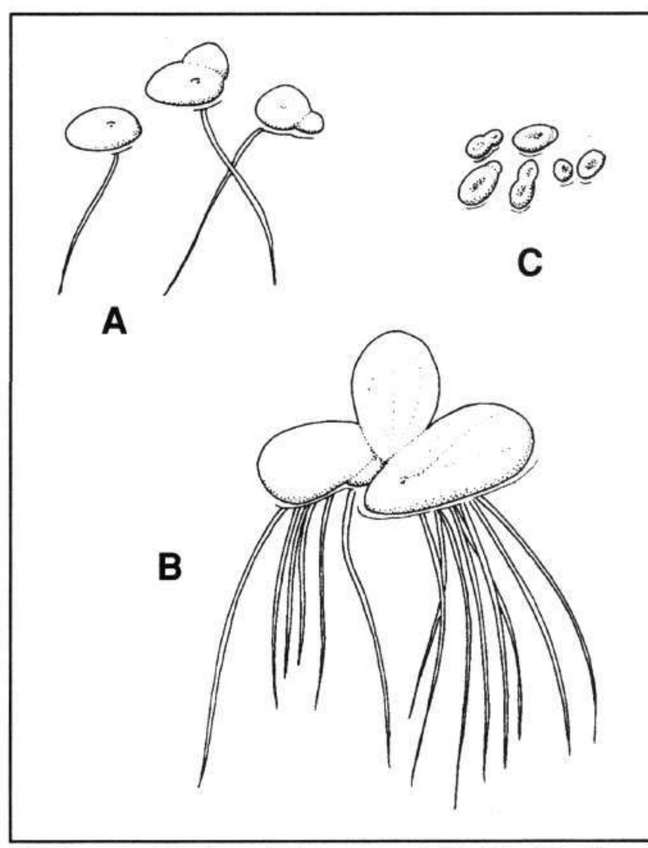
Elodea is similar in appearance to another plant called **hydrilla** *(Hydrilla verticillata)*. Hydrilla is not native to North America and is a serious nuisance in lakes of the southern United States. It is distinguished from elodea by having five leaves in each whorl and a ridge of micro-fine spines on the midrib on the lower side of the leaf. It is not currently thought to be in Michigan, but if it is found or suspected, notify the MDNR immediately.

Free-Floating Plants

Duckweed and Watermeal

It is difficult to maintain control of **duckweed** and **watermeal** *(Lemna* spp., *Wolffia* spp., *Spirodela* spp.). Duckweed is a tiny, green, floating, oval plant often mistaken for algae. Roots may or may not extend from the underside. Duckweed reproduces by division and is common in quiet water such as ponds and backwaters.

Watermeal is the smallest of flowering plants, granular in size and usually very abundant when present. These tiny, floating, green plants do not have roots extending from the underside and are often mistaken for seeds. Because duckweed and watermeal are floating plants, both obtain their nutrients directly from the water, not a substrate.

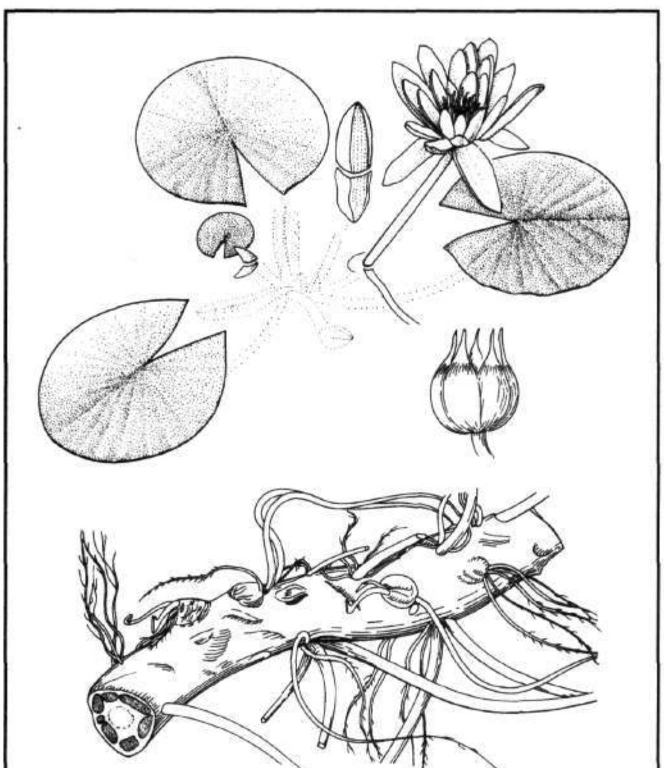


(A) Common Duckweed *(Lemna* spp.*)*, (B) Giant Duckweed *(Spirodela* spp.*)*, and (C) Watermeal *(Wolffia* spp.*)*

Duckweed and watermeal are noted for their rapid reproduction. When they become a nuisance, harvesting is not a feasible option because they pass through the belting. Effective herbicide control depends upon chemical contact with as many of the plants as possible. This includes those washed up along shorelines or trapped in backwater areas. The minute size of these plants makes it very easy for water to wash the herbicides off. Addition of a sticker (adjuvant) is recommended by most manufacturers to aid in maintaining herbicide contact with emergent plants.

Rooted Floating Plants

Waterlilies or lily pads (*Nymphaea* spp., *Nuphar* spp.) are valued for fish cover and for their showy flowers, and they are often best left alone. Lily pads' flower color may be white, yellow or pink depending on the species or hybrid. Leaves range from 6 to 16 inches in diameter and may be heart-shaped or round with a **cleft** (a cut about halfway to the midvein of the leaf). Lily pads are common in shallow water and prefer muck or silt bottoms. Water lilies spread horizontally from thick, fleshy rhizomes. The white water lily is able to tolerate a wide range of water pH.

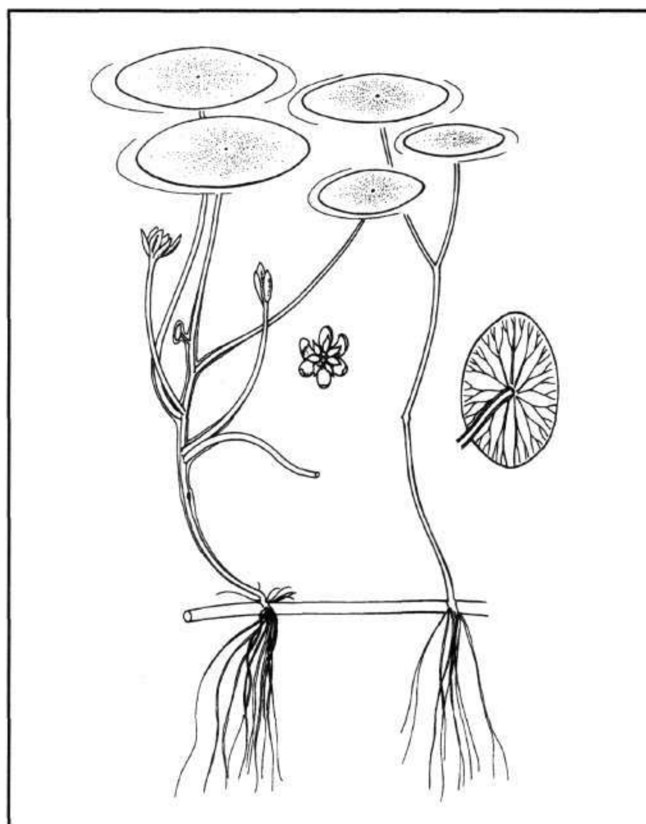


Waterlily *(Nymphaea spp.)*

Waterlilies may be intentionally planted for their beauty and their contribution to fish habitat. Some species are quite prolific and can create a nuisance problem. If management treatments are needed, use the same strategy as for cattails. (See below.) Always consult the herbicide label for specific use, timing and rates. Because of the tough nature of the lily pad leaf and the **petiole** (the stalk of the leaf), it may take some time for the plant material to decompose.

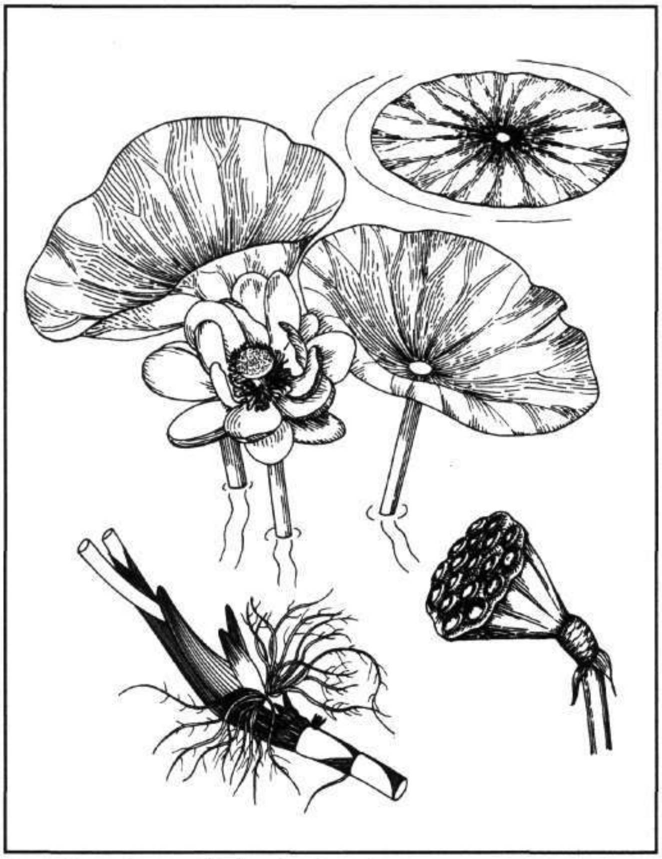
Watershield plants *(Brasenia schreberi)* look similar to lily pads. They are found in shallow, acid waters throughout the eastern United States. Watershields have oval to elliptical leaves with smooth, unlobed edges. The petiole is attached to the middle of the leaf. The leaves may be 2 to 5 inches long. A slimy, gelatinous coating covers the underside of leaf and stem, particularly on mature plants. A dull, reddish purple flower is produced in early summer.

If watershield becomes a nuisance and a liquid herbicide treatment is made, take care not to wash the chemical off the leaf surfaces. Treat early in the season before the gelatinous coating develops.



Watershield *(Brasenia schreberi)*

American lotus *(Nelumbo lutea)* grows in shallow areas of lakes and in slow-moving water. Plants have large, circular leaves up to 2 feet in diameter that extend above the water surface. The stem is attached in the center of the leaf, which is frequently cup-shaped. The seeds of this plant are a valuable food for waterfowl; the starchy rhizomes are also edible. Lotus plants provide shade and cover for fish. The seed pods are sometimes sold commercially for flower arrangements. This plant does not normally constitute a nuisance.

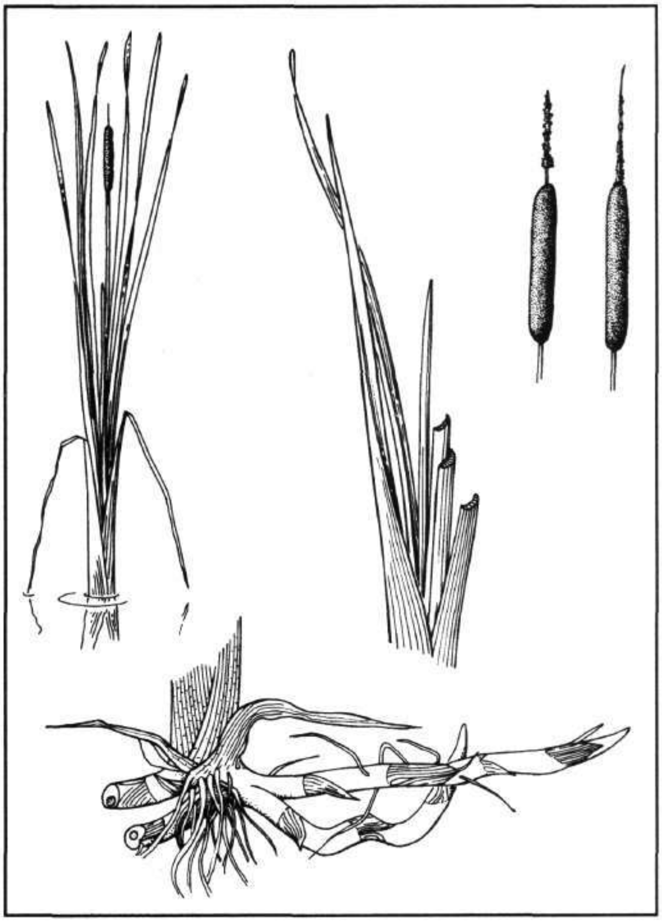


American Lotus *(Nelumbo lutea)*

Emergent Plants

Cattails *(Typha* sp.*)* are highly regarded wetland plants that provide food and shelter for many species of wildlife and fish. Cattails have long, slender, grass-like stalks up to 10 feet tall. Cattails inhabit wet lowlands and water to 4 feet deep.

Cutting mechanically or by hand during the growing season gives temporary relief but requires repeated treatment throughout the season. Cutting off cattails at ice level during the winter sometimes reduces their stands the following year. Effective herbicide management options for cattails require either applying certain contact herbicides before seedheads form or using a systemic herbicide before or after seedheads form. Consult the pesticide label for recommended timing and rates of systemic herbicides.



Cattail *(Typha* spp.)

Purple loosestrife *(Lythrum salicaria)* is an exotic, invasive species that outcompetes beneficial shoreline and wetland vegetation. It is very prolific (up to 300,000 seeds per plant) and has an extensive root system. People have aided its spread by using it as an ornamental plant. The purple flower spike is quite attractive.

The plant is of little value to wildlife and should be controlled as soon as infestations are discovered to prevent beneficial vegetation from being choked out. Treatment with a contact herbicide before flowering can be effective. Treatment with a systemic herbicide is best. Perform systemic herbicide treatments before seed formation to reduce seed dispersal and enhance long-term control.

See pages 73-76 for photographs of aquatic plants commonly found in Michigan.

Chapter 5 – Aquatic Plant Identification and Management Review Questions

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

1. Which statement concerning algae is incorrect?
   a. Algae are classified as being either planktonic, filamentous or erect.
   b. Algae reproduce by cell division, plant fragmentation or spores.
   c. All algae obtain energy from sunlight.
   d. Algae are simple plants with true roots.

2. What organism is commonly referred to as "pond scum"?

3. Eurasian watermilfoil and curly-leaf pondweed are examples of _______________ plant species that can form dense mats of near-surface vegetation over expansive areas and adversely affect water chemistry and degrade fisheries.

4. What necessary and beneficial roles do native plants fulfill in their aquatic ecosystem?

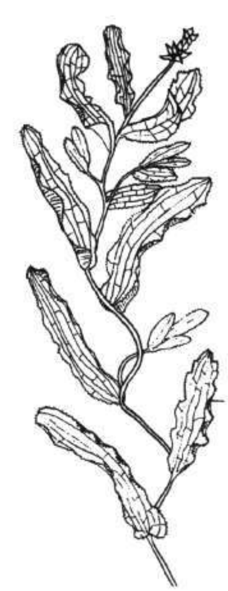
   1.

   2.

   3.

5. Which is not a characteristic of the watermilfoil species?
   a. Most are exotic plants requiring management.
   b. They are members of the genus *Myriophyllum*.
   c. They reproduce mainly by fragmentation and rhizomes.
   d. The major watermilfoil of concern in the United States is the Eurasian watermilfoil.

6. Name the plant shown below.



7. _______________ are dormant root structures that are not affected by herbicides and are used primarily for reproduction in the curly-leaf pondweed.

8. If large amounts of plant material die and decompose when water temperatures are high, the potential for oxygen stress on the water body and its aquatic organisms is great.
   True or False?

9. Naiads differ from many other aquatic pest species in that they are _______________ and overwinter as _______________.

10. Which is not a characteristic of coontail?
   a. It has clusters of finely forked leaves that appear bushy at or near the end of the stem.
   b. It is a hardy plant with long, limp, ribbon-like leaves arising from the base of the plant.
   c. It harbors significant amounts of food for fish and waterfowl in its branches.
   d. Because of fragmentation, harvesting of coontail is not recommended.

11. To control wild celery or tape grass, try hand pulling, raking or screening the bottom, but not herbicide treatments. True or False?

12. Name the aquatic organism shown below.

13. What free-floating, tiny, green, oval plant reproduces by fragmentation and is common in quiet water?

14. Which statement about rooted floating plants is not true?
   a. They do not normally constitute a nuisance.
   b. Waterlilies are valued as fish cover and for their showy flowers.
   c. It is best to treat watershield chemically after its gelatinous coating develops.
   d. The seeds of the American lotus are a valuable food for waterfowl, and their rhizomes are also edible.

CHAPTER 6

NONCHEMICAL AQUATIC VEGETATION MANAGEMENT TECHNIQUES

As mentioned in Chapter 3, "Integrated Pest Management," careful site evaluations are important information-gathering activities for pest managers. A successful management program for a body of water includes an accurate assessment of the types and numbers of plant species found in the area. Various plants serve different purposes and may or may not be nuisances.

Identifying the components within an aquatic plant community is necessary for short- and long-range planning. How each type of plant will fit into the long-range goal must be considered. Plant groups may be contained, eradicated, encouraged or restored. The management strategies that you use influence the composition among plant communities. This influence is often called selectivity.

Using a particular method will favor the production of some plant species or species groupings because it gives these species a competitive advantage over other species. Other species may be contained or eradicated by the application of a certain method or strategy. Some plant species will show little response to certain strategies. The selectivity issue is complicated by many interactions that influence the outcome of a particular management strategy in a particular lake.

Ideally, the aquatic pest manager has discussed short- and long-range expectations of the site with persons and associations responsible for the lake environment. Management plans should specify what plants will be maintained and those that will be contained, and establish priorities to achieve the stated goals. Not only is it possible to integrate several methods or strategies into the short- and long-range management plans, but it is usually necessary.

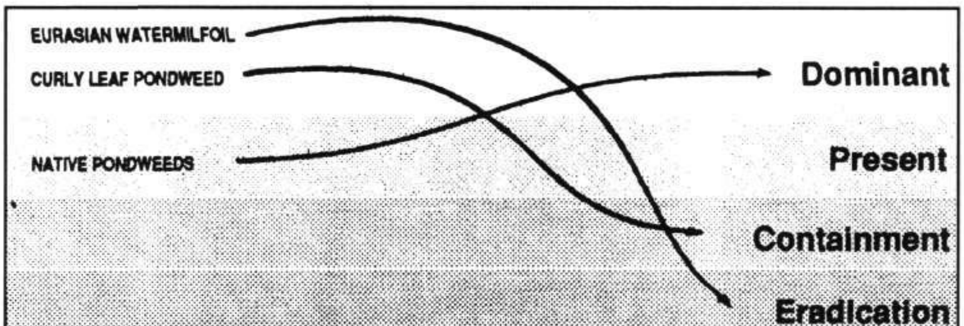
When evaluating aquatic weed problems, consider all methods of control: preventive, mechanical, cultural, biological and chemical.

Preventive Control

Preventive control of aquatic weeds has three major objectives: preventing weed spread, eliminating nutrient sources that support growth, and deepening or increasing the slope of shallow areas where plants can grow.

Preventing Aquatic Weed Spread

Aquatic plants seem to appear quickly in new ponds or lakes, even though they may be isolated from other bodies of water. Algal spores can be carried by wind. Plant propagules — spores, seeds, turions, tubers— and plant fragments can be carried on the feet or feathers of waterfowl or the fur of mammals. People are also primary movers of aquatic weeds, transporting plant



A diagramatic representation of how a species selective vegetation management strategy might be applied to contain or eradicate some species and restore other species to a predominant position in the lake flora.

propagules on boats and boat trailers. Using aquatic plants to provide packing or shade for bait minnows or worms, and disposing of aquarium plants through sewer systems are also believed to contribute to the spread of aquatic plants. It is nearly impossible to prevent the spread of aquatic weeds by animals, wind or water but many human activities that spread weeds can be prevented.

If a small clump of a particularly objectionable aquatic weed species appears in a pond or lake channel, it should be removed immediately, either by hand or with chemical spot treatments. Control these plants before they flower and form seeds. This is particularly important with exotic species such as Eurasian watermilfoil and curly-leaf pondweed.

Nutrient Management

A major emphasis during recent years has been placed on the management of nutrient loading to streams and larger water bodies such as lakes and reservoirs. The addition of nutrients increases production of plants and algae and causes the lake's ecosystem to age and deteriorate. This process is called **eutrophication**. Phosphorus is the nutrient of most concern, though nitrogen loading has also received significant attention and abatement measures largely because of public health concerns over nitrate levels in drinking water. Carbon also enhances aquatic plant production. Carbon supplies sufficient to support extensive plant growth can enter water from the atmosphere in the form of carbon dioxide or in water as dissolved bicarbonate (HCO_3) compounds.

Nitrogen is available from many sources, including rain, lightning, groundwater, the fixation of atmospheric nitrogen by blue-green algae, agricultural practices and lawn fertilization. For many lakes and streams, however, the major inputs of nitrogen and phosphorus are from **point sources** (single location of discharge or release) such as sewage treatment plants, septic tanks, and feedlots. Most of these sources can be identified and appropriate steps initiated to control their release of nutrients. For example, phosphorus can be partially removed through tertiary treatment at sewage treatment facilities, drainage from feedlots can be controlled, sewer systems can be installed in place of inadequate septic systems and the use of phosphate detergents can be minimized.

Not all water bodies obtain nutrients from point sources. When nutrient inputs or other contaminants are from **non-point sources,** control is much more difficult. Non-point-source pollution results from land runoff, precipitation, acid rain or percolation rather than from a discharge or release at a specific, single location. Watershed alterations and management practices to reduce nutrient and other contaminating inflows include:

1. Installing vegetation or grass sod along drainage areas and around receiving waters to prevent runoff and absorb nutrients (wetlands play a key role in this type of nutrient filtering).

On waterfront properties, avoid the use of fertilizers containing phosphorus, and do not fertilize close to water bodies; leave a 10-20 foot buffer strip.

2. Discontinuing turfgrass fertilization in a 10- to 20-foot strip around the body of water or, if this area requires fertilization, using only fertilizers **without** phosphorus on a limited basis. Fertilization of high maintenance lawns and golf courses can be a major source of nutrients in ponds and lakes.
3. Preventing livestock from entering the body of water. Animals not only fertilize the water but tear down banks and increase soil erosion.
4. Practicing conservation tillage methods in areas that are subject to severe soil erosion.
5. Constructing a settling pond to receive nutrients before the flow reaches the main body of water (in cases where nutrients may be entering by means of sediments in an inflowing stream).
6. Constructing wetlands. These may be a series of small ponds and areas planted with emergent wetland vegetation. When properly engineered, constructed wetlands can effectively remove nutrients, such as phosphorus, from inflowing water.
7. Avoiding adding fertilizers to a body of water. In fact, except in certain commercial fish production operations, fertilizers should

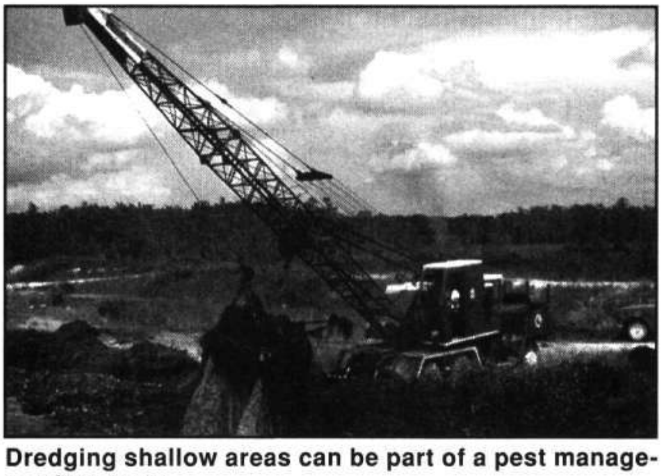
never be added to a body of water. In Michigan, the waters are usually sufficiently rich in plankton and other food organisms to support large fish.

8. Checking for hidden sources of nutrients such as septic fields and drainage tiles. Septic systems can be checked using dyes available from state or local health boards.
9. Planting deciduous trees far enough from water bodies so leaves will not fall into the water and accumulate.

Techniques to reduce nutrients in a body of water have been most effective for controlling organisms, such as phytoplankton, that receive nutrients from the water. Even though every effort should be made to reduce nutrient inputs into water, most evidence suggests that these efforts are unlikely to decrease the growth of established rooted plants. Reducing nutrient inputs to control rooted plants may be helpful in the long term for older lakes but is probably most effective in lakes where sediments have not become heavily loaded with nutrients.

Engineering Shallow Areas

New ponds and lakes should be constructed to avoid extensive areas less than 3 feet deep. Shoreline edges should be deepened to at least 3 feet to reduce sites for rapid establishment of plants. The only exception should be swimming areas, in which sharp drop-offs may be hazardous to small children.



Dredging shallow areas can be part of a pest management program.

Shallow areas in existing ponds or lakes can be deepened with dredges or draglines to create a slope of 3:1 to a depth of 6 to 8 feet. Removing sediment also removes nutrients and plants. A dumping site away from the water's edge must be available for the removed hydrosoils. Be sure you have all permits required for these activities.

Mechanical Control

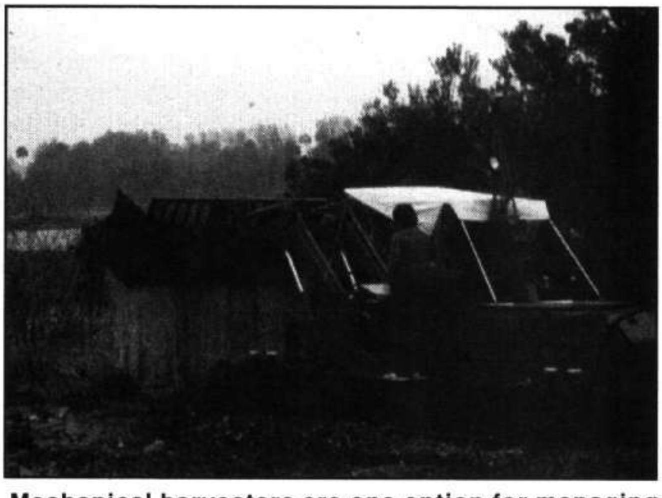
Mechanical methods to remove existing stands of aquatic weeds include:

- Hand pulling.
- Raking.
- Using mechanized equipment.

Hand removal can be effective, but it is extremely time consuming and laborious. Regrowth from seeds and underground plant parts can be expected.

Mechanized equipment includes a variety of dredging machinery and weed cutters. Draglines are commonly used to remove vegetation and sediments from irrigation and drainage ditches. Draglining is an effective weed control method, but it is expensive and usually needs to be repeated every three to four years. Permits are required to perform dredging.

Weed cutters cut underwater rooted vegetation 4 to 6 feet below the water surface. They are used primarily on large lakes or rivers. Most machines



Mechanical harvesters are one option for managing aquatic weed populations.

also remove, or harvest, the cut material from the water body. Cutting/harvesting has several advantages. All types of aquatic vegetation, including filamentous algae and vascular plants, can usually be removed. The technique can be practiced under most non-windy conditions, and there are no restrictions on the amount of area to be cut or the use of the water following treatment.

Weed cutters that do not harvest the plants are not recommended because cut plant fragments can live for long periods of time floating in water. These plant fragments develop roots and can invade other areas. The cut fragments may also collect along shorelines and create a considerable mess along lakefronts and in swimming areas.

Aquatic weed cutters that harvest the cut plant material prevent it from decomposing in the water. Removing plant material reduces the risk of fish kills due to suffocation caused by decomposing plant material and resulting oxygen depletion and, to some degree, removes nutrients.

Only a small portion (2 to 3 percent in some cases) of a lake's total nutrient content is contained in the aquatic weeds. Over a long period of time, harvesting may lower the nutrient content of a body of water, if new nutrient inputs are prevented from entering the lake and nutrients are not recycled from the sediments.

Several factors should be considered before you invest in a mechanical harvester. Purchase and maintenance costs can make these machines an expensive form of weed control. Mechanical harvesting is like mowing a lawn — plants continue growing from the uncut portions, so harvesting must be done several times during the season to maintain open water.

Mechanical harvesters are not suitable for removing vegetation in water less than 1 to 3 feet deep, so many bodies of water will be too small for the large commercial equipment currently manufactured. Some aquatic managers in Michigan construct their own equipment to harvest plants from small lakes and ponds. Harvesting equipment may be classified as heavy equipment and can be dangerous if operated improperly. Most machines are operated hydraulically. Hoses, fittings and valves must be properly maintained to prevent leakage or loss of hydraulic fluid and pollution of lakes. Permits may be required to transport harvesters on public roads and to launch them from public access sites.

Another consideration with mechanical harvesting of aquatic weeds is vegetation disposal. A dumping area must be available from which vegetation cannot wash back into the lake. Harvested aquatic weeds can be used as mulches or fertilizers in gardens and fields. Considerable research is being conducted to determine other potential uses. Some possibilities include using the harvested aquatic plants as livestock feed or as sources of methane gas. Fines may be levied if harvested plant material falls off transport trucks en route to disposal sites.

A disadvantage to weed cutting and harvesting is that the initial process is **nonselective**. All plant types growing among the weeds, both nuisance and desirable species, are removed. When harvesting is used over several years, some highly undesirable plants such as Eurasian watermilfoil may become the predominant species and more desirable plants may be excluded. Fish and small organisms that live in the weeds are also commonly victims of harvesting. Wise use of several management techniques will avoid this nontarget impact and long-range selectivity of potentially undesirable species.

Finally, the plant stubble that remains after harvesting may relaese nutrients into the water. It is not uncommon for water clarity to decline immediately following a harvesting operation because of sediment suspension or algae blooms. This condition is usually temporary and water quality is typically restored within a few days.

Cultural Control

Cultural weed control can also be used at aquatic sites. It involves altering the environment in which the weeds are found. Altering the habitat where weeds prefer to grow will discourage their establishment or reproduction. Examples include the following:

1. The shoreline can be lined with rocks or other types of rip-rap to prevent both erosion and establishment of aquatic weeds. Public Health Code Act 346 of 1972, also known as the Inland Lakes and Streams Act, requires a permit for this type of activity.
2. Winter drawdowns are effective for controlling many submersed and rooted floating weeds. This technique involves exposing the shallow areas to drying and freezing conditions. Drawdown can be achieved with structures built to control water flow into the pond, lake or ditch, the installation of siphoning systems to lower the water level, or naturally as a result of receding shorelines during periods of low rainfall.

   One of the benefits of a partial drawdown is to concentrate the fish in a small, deep area away from the shallow weed zone.

Concentration enables more effective predation of small fish by large fish, which may result in an improvement in fish quality. Another benefit is the drying and consolidation of the sediments, which slightly deepens the water body. Drawdowns may also restructure the species composition of the lake flora. Naiads and milfoil may become dominant as a result. Table 6-1 outlines the effect of winter drawdowns on a variety of aquatic plant species. Act 346 permits are required to perform drawdowns.

3. Covering bottom sediments with black plastic, landscape fabric or other light prevention materials can be useful on a small scale for controlling submersed weeds. Several bottom-covering materials are commercially available. They are all called **benthic barriers.** The best benthic barrier is gas permeable and opaque and cannot be penetrated by plant roots or vegetation.

   Areas suited for this technique include boat dock areas and swimming beaches. The material may be installed during impoundment construction, drawdown or ice cover and weighted with sand or gravel. Benthic barriers must be securely fastened to a substrate to prevent their being buoyed upward by the gases naturally produced in the underlying sediments.

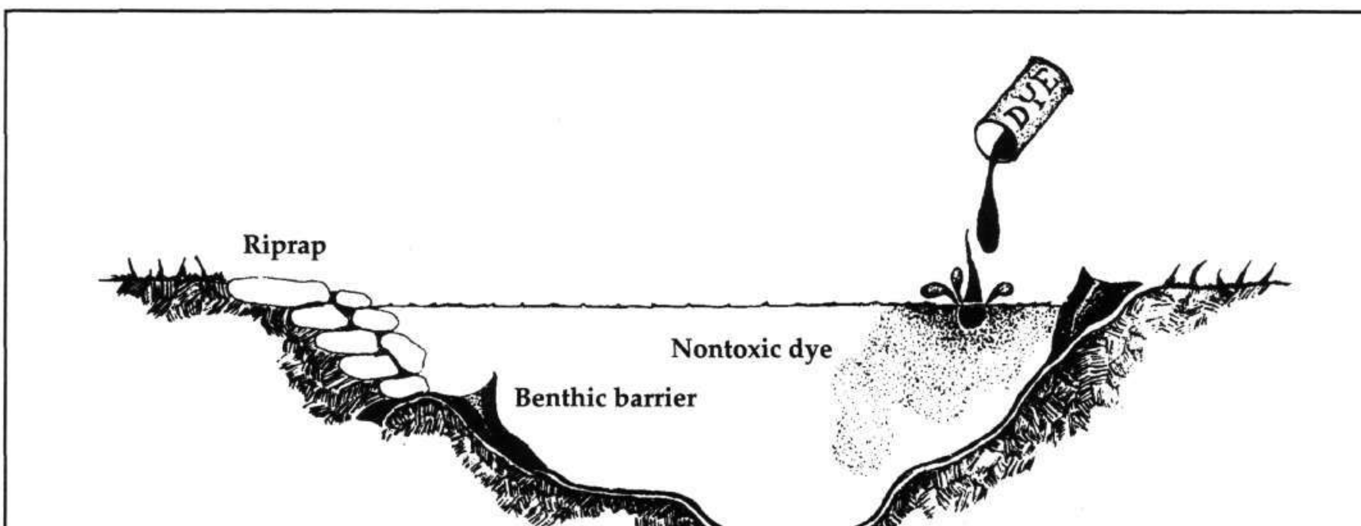
   Recognize that plastic becomes brittle over time and may break apart and float to the water surface. These pieces of plastic or other benthic barrier material are unsightly, may create a swimming hazard and can damage boat motors if they become entangled in the propellers. Aquascreen is a window screen-like material that resists tearing and is anchored to the sediment with spikes. Act 346 permits are required for installing benthic barriers.

4. Nontoxic dyes, which act as light screens, can be used to inhibit submersed plant growth. An example is a blue dye that absorbs light that plants would otherwise use for photosynthesis. This dye can be applied easily, disperses readily in a body of water and reduces plant growth. The dye concentration must be maintained throughout the growing season, so its use is limited to ponds with no outflow.

   Also, dyes must be applied before weeds emerge in the spring. Once weeds reach the water surface, the dye has little effect. In the Midwest, an initial application and a mid-season application are suggested.

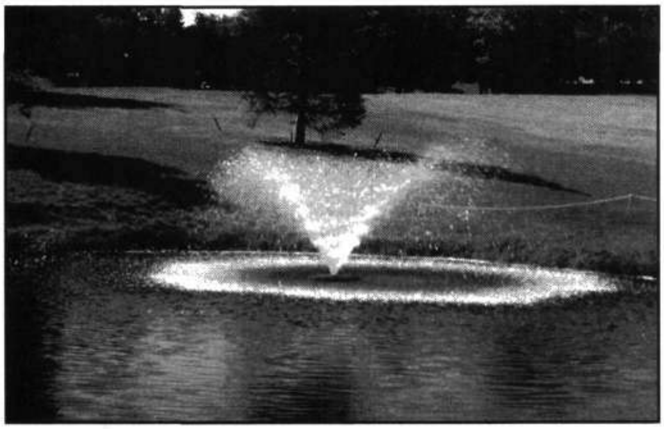
   Some dyes are registered as pesticides: others are not. Only dyes approved for use in ponds should be used. Act 368 requires permits to use dyes.

5. Aeration may control algae but does not affect macrophytes. If this process is not done correctly or thoroughly, the aquatic algae problem may increase. Aeration can increase aquatic plant problems by bringing nutrients that were trapped in the colder, deeper water to the surface, causing an algae bloom. To date, the benefits derived from controlling aquatic weeds or algal blooms by this technique in small ponds and lakes have not adequately been demonstrated. The primary benefit of aeration may be to prevent oxygen



Types of cultural control.

depletion during the summer or winter and thus, to prevent fish kills.



The effectiveness of aeration techniques for reducing algae popluations is disputed.

In deep, thermally stratified lakes, aeration/destratification methods and devices have reduced phytoplanktonic algae production and shifted the species dominance from blue-green algae to more desirable species. Destratification techniques can alter nutrient and gas concentrations in the water column.

Susceptible to drawdown:
- Large-leaf pondweed *(Potamogeton amplifolius)*
- Waterlily *(Nymphaea tuberosa)*
- Watershield *(Brasenia schreberi)*

Moderately tolerant to drawdown:
- Leafy pondweed *(Potamogeton foliosus)*
- Richardson's pondweed *(Potamogeton richardsonii)*
- Water smartweed *(Polygonum natans)*

Tolerant to drawdown:
- Bulrush *(Scirpus validus)*
- Cattail *(Typha latifolia)*
- Coontail *(Ceratophyllum demursum)*
- Sago pondweed *(Potamogeton pectinatus)*

Predominance enhanced by drawdown:
- Naiads *(Najas* spp.*)*
- Milfoils *(Myriophyllum* spp.*)*
- Curly-leaf pondweed *(Potamogeton crispus)*

Effect of winter drawdown on some aquatic plant species.

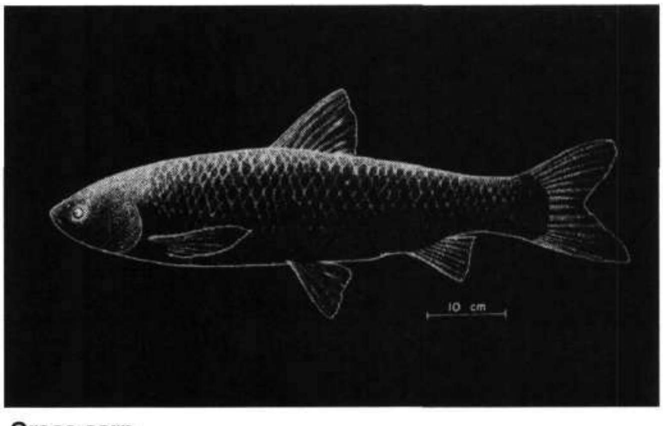
Biological Control/Biomanipulation

Biological controls include strategies that introduce or enhance the production of organisms that restrict pest species.

Biological controls may be introduced to encourage and/or artificially increase plants and animals that are parasites or predators of a pest. Biological controls are most commonly used to manage insects, mites and some weeds in terrestrial settings. Aquatic pest managers in Florida have been successful introducing several insects that provide varying levels of control of aquatic weeds such as alligatorweed, water hyacinth, hydrilla and water lettuce. Florida's pest managers have also attempted to use snails, manatees, ducks, crayfish and water buffalo to biologically control aquatic weeds. Most of these practices are not practical in Michigan.

Herbivorous (plant feeding) fish have also been used as a biological control for aquatic weeds. Fish species native to the United States do not normally feed on rooted vegetation, so strictly vegetarian species have been introduced. The two most notable species introduced include the tilapia *(Tilapia* or *Sarotherodon)* and the grass carp or white amur *(Ctenopharyngodon idella)*. The use of these fish is strictly **prohibited in Michigan** at this time because of many disadvantages described below.

The grass carp is a strict vegetarian, feeding on filamentous algae, *Chara*, submersed weeds and the duckweeds. It may also eat vegetation just above the water line, although it is not generally considered an effective control for emergent vegetation or large free-floating weeds. These wild-type grass carp are nonselective, eating all plant types, and have no limits to the quantity of vegetation they consume as their population grows. Because of this, it has been difficult to establish appropriate stocking rates. A limited number of grass carp can devastate an aquatic environment by eating too much vegetation. These fish tend to



Grass carp.

prefer, and therefore eat, the more desirable native Michigan plant species before consuming the exotic species that cause the greatest nuisance. The use of grass carp is inconsistent with management practices that are intended to provide a balanced plant community. When too much vegetation is consumed, the plant species found in that community may ultimately be replaced by planktonic algae, which these fish cannot eat.

Many states have laws banning the importation of the grass carp, but the triploid (sterile) grass carp is now allowed in some states (not in Michigan) under strict permit rule and supervision.

Biomanipulation of an aquatic site is the alteration of the food web to improve water clarity by enhancing biological activities. The following strategy for managing nuisance planktonic algae illustrates biomanipulation. If the effectiveness or the number of organisms that feed on nuisance planktonic algae is increased, the levels of planktonic algae will decrease. This can be accomplished by manipulating the food web so that zooplankton are able to increase in numbers and feed on the suspended algae. This may require removing fish from the lake and then restocking it with an appropriate fish species.

Sites that would be good candidates for the application of this biomanipulative strategy are small lakes or ponds that are filled with stunted sunfish and characterized by high turbidity. Results are not always predictable. It is highly recommended that this strategy be applied only with the assistance of a biologist knowledgeable and experienced in the use of biomanipulative planktonic algae management strategies. More research is needed to bring this technique into common practice.

Chapter 6 – Nonchemical Aquatic Vegetation Management Techniques Review Questions

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

1. The three major objectives of preventive aquatic weed control are:

2. It is possible to prevent the spread of aquatic weeds by animals, wind or water. True or False?

3. Describe the process of eutrophication.

4. The major inputs of nitrogen and phosphorus from single locations of discharge or release are called______________________________.

5. Control of contaminants is much more difficult if they are from:

   a. Point sources.

   b. Non-point sources.

   c. Sewage treatment plants.

   d. Feedlots.

6. List five of the eight methods for reducing nutrient and other contaminating inflows to water sources.

   1.

   2.

   3.

   4.

   5.

7. Which is not true about draglining as a means of mechanical control?

   a. It is an effective weed control method.

   b. It removes vegetation and sediments from irrigation and drainage ditches.

   c. It is inexpensive and needs only to be preformed once.

   d. Permits are required to perform dredging.

8. Mechanical harvesting is like mowing a lawn — plants continue growing from the uncut portions — so harvesting must be done several times during the season to maintain open water.

   True or False?

9. Which of these statements about cultural weed control is true?
   a. Lining the shore with rocks to prevent erosion and establishment of weeds does not require a permit.
   b. One of the benefits of a partial drawdown is to concentrate the fish in a larger, shallow area away from the weed zone.
   c. The best benthic barriers are gas permeable and opaque and cannot be penetrated by plant roots or vegetation.
   d. Aeration controls algae and macrophytes.

10. Which statement concerning aeration is false?
    a. If not done correctly or thoroughly, the aquatic algae problem may increase.
    b. Aeration can bring nutrients that were trapped in the colder, deeper water to the surface, causing algae bloom.
    c. The benefits derived from aeration to control aquatic weeds or algal blooms outweigh the potential problems.
    d. The primary benefit of aeration may be to prevent oxygen depletion during the summer or winter to prevent fish kills.

11. Which species is(are) susceptible to drawdown?
    a. Water smartweed (Polygonum natans)
    b. Large-leaf pondweed (Potamogeton amplifolius)
    c. Watershield (Brasenia schreberi)
    d. Sago pondweed (Potamogeton pectinatus)
    e. Both a and b.
    f. Both b and c.

12. ____________________ controls include strategies that introduce or enhance the production of organisms that restrict pest species.

13. The grass carp:
    a. Is not considered an effective control for emergent vegetation or large free-floating weeds.
    b. Is selective in the plants types it feeds on.
    c. Has stable consumption habits, which makes stocking rates easy to establish.
    d. Is allowed in Michigan if it is sterile.

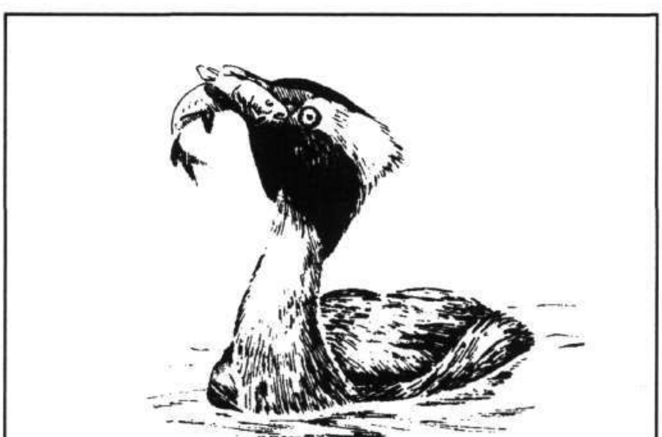
14. ________________________________ is the alteration of the food web to improve water clarity by enhancing biological activities of an aquatic site.

CHAPTER 7
HERBICIDE TECHNOLOGY AND APPLICATION CONSIDERATIONS

Aquatic herbicides can be used to manage aquatic vegetation effectively and cost efficiently. A herbicide formulation consists of an organic (carbon-containing) or inorganic active ingredient, an inert carrier and perhaps adjuvants. Every herbicide must be registered for use in the United States by the Environmental Protection Agency and a registration fee paid to the Michigan Department of Agriculture before it can be used here. About 200 herbicides (active ingredients) currently registered in the United States, but fewer than 10 are labeled for use in aquatic sites in Michigan.

The reason there are few aquatic herbicides is that the aquatic environment limits the number of compounds that will be effective for controlling aquatic plants and at the same time meet the rigid environmental and toxicological criteria necessary for registration. Aquatic herbicides must have the capacity to be taken up from the water by plants quickly and in sufficient amounts to be toxic to target plants and have sufficiently low toxicity to humans and to other organisms in the aquatic environment.

Several herbicides are packaged in a number of formulations, most of which are not registered for aquatic use. Always use the product labeled for aquatic sites — only these products offer low risk and effective control and have labels with the appropriate use information for aquatic settings. Applying unlabeled products or products that do not specify aquatic sites violates both federal and state laws and regulations and may severely damage the environment and possibly harm the user.



Aquatic herbicides and algaecides come in various formulations and can be used in a variety of situations. With careful selection and proper application rates and timing, aquatic herbicides are a selective (removing only the target pest without harming other species) lake management tool. Selectively removing exotic and other nuisance species can shift lake flora to more desirable native species that provide better habitat for fish and invertebrates.

Herbicide Selection

Several factors need to be considered in planning a successful aquatic herbicide program:

(1) proper identification of the weed or weeds;

(2) uses of the water to be treated;

(3) goals outlined in the lake's management plan;

(4) timing of the treatment;

(5) water characteristics, including temperature, $CaCO_3$, alkalinity, percent saturation of dissolved oxygen (D.O.), and water flow;

(6) method of application;

(7) probability of re-treatment, potentially within the same year;

(8) impact on nontarget plants and animals;

(9) weather — sunny, cloudy, rain; washout potential;

(10) cost; and

(11) permits and permission from appropriate agencies and property owners/managers to perform the treatment.

ABSORPTION CHARACTERISTICS
Contact herbicides: copper, dibromide, endothall **Systemic herbicides:** 2,4-D, dichlobenil, fluridone, glyphosate
PHYSIOLOGICAL PROCESSES
Cell Division: dichlobenil **Tissue Development:** 2,4-D **Photosynthesis:** copper, dibromide, fluridone **Respiration:** endothall **Nitrogen Metabolism and Enzyme Activity:** glyphosate
SELECTIVITY*
Nonselective (broad-spectrum): copper, dibromide, endothall, glyphosate, dichlobenil **Selective:** 2,4-D, fluridone (rate dependent) * Selectivity depends on application rate and timing. Each of these compounds may be broad-spectrum or selective, depending on how they are used.

Table 7.1. Classification of aquatic herbicides and algaecides.

Herbicide Classification

Herbicides are commonly grouped according to chemical similarity or herbicidal properties. Properties by which herbicides are grouped are absorption characteristics, the plant processes that they affect and selectivity (Table 7.1).

Absorption Characteristics

Contact Herbicides

Contact herbicides act quickly and are generally lethal to all plant cells that they contact. Because of this rapid action or other physiological reasons, they do not move extensively within the plant and are effective only where they contact plants. For this reason, they are generally more effective on annual herbaceous plants. Perennial and woody plants can be defoliated by contact herbicides, but they can regrow from unaffected plant parts. Because contact herbicides do not kill the entire plant, re-treatment is necessary, sometimes two or three times per year.

Systemic Herbicides

Systemic herbicides are absorbed into the living portion of the plant and move within the plant (translocation). Systemic herbicides are absorbed at varying degrees by various plant parts. Systemic herbicides that are absorbed by plant roots are referred to as soil-active herbicides; those that are absorbed by leaves are referred to as foliar-active herbicides.

When applied correctly, systemic herbicides act slowly compared with contact herbicides. They must move to the part of the plant where the control action takes place. Systemic herbicides are generally more effective than contact herbicides for controlling perennial and woody plants. Systemic herbicides generally have more selectivity than contact herbicides.

When using systemic herbicides, use only the amount necessary for control. This amount will never exceed label rates but may be lower than label rates under some situations. Using some pesticides at labeled rates may result in a systemic herbicide working like a contact herbicide. Exceeding label rates is not only illegal but may cause the foliage to "burn" off before it can absorb and translocate the herbicide throughout the plant and into the root system. This leaves the roots intact and able to generate new top growth. This situation may lead to the undesirable need for additional treatments later in the season.

Plant Processes and Herbicidal Activity

Cell Division

Plants grow by increasing their number of cells and replacing old cells. This process is called cell division. If a herbicide can stop cell division by affecting one of the many complex processes involved, it can stop the plant from growing. If cell division is sufficiently affected, the plant will die. Herbicides that affect cell division are most effective when they are applied **preemergence** (before weed seeds germinate and begin to grow) or during early growth.

Tissue Development

During tissue development, plant cells become specialized and organized into units that perform particular functions in the plant. When a herbicide causes abnormal tissue development, abnormalities such as twisting of stems and leaves may be evident. If sufficient abnormalities occur, plants can die. Herbicides that act in this manner are often called plant growth regulators (PGRs). 2,4-D is an example of a herbicide that interferes with tissue development.

Photosynthesis

Photosynthesis is the process by which plants use carbon dioxide, water and sunlight to produce molecules that are the building blocks for other more complex molecules that make up the plant body. Photosynthesis is a very complex process, and various herbicides disrupt it in different ways. Plant death may be slow when the photosynthesis process is disrupted.

Respiration

Plants produce compounds such as sugars and carbohydrates during photosynthesis. Plants then use these compounds through a series of processes known as respiration. Many herbicides affect respiration, although these are probably secondary reactions.

Nitrogen Metabolism and Enzyme Activity

Nitrogen is an essential plant nutrient and is involved in many plant processes. Its absorption and incorporation into plant compounds is referred to as nitrogen metabolism. Complex nitrogen-containing compounds called enzymes are essential to plant processes. Many herbicides affect plants by interfering with the enzymes associated with the processes.

Selectivity

Broad-Spectrum Herbicides

Broad-spectrum (sometimes referred to as non-selective) herbicides are used to control all or most vegetation. Glyphosate is an example of a broad-spectrum herbicide. Broad-spectrum aquatic herbicides can be used selectively under certain circumstances discussed later.

Selective Herbicides

Selective herbicides are those that are used to control certain plants but do not affect others. An example is 2,4-D, which can be used to control broad-leaved weeds with minimum impact on grasses. Herbicide selectivity is based on various plants' susceptibility or response to herbicides. Many related physical and biological factors contribute to a plant's susceptibility to a herbicide. Physical factors that contribute to selectivity are:

- Herbicide placement.
- Formulation.
- Rate of application.

Biological factors that affect herbicide selectivity are :

- Physiological factors.
- Morphological factors.
- Stage of plant growth.

Selective application can be as simple as carefully placing the herbicide on target plants and avoiding nontarget plants. For example, when small amounts of purple loosestrife are growing among cattails, an experienced applicator using a handgun can control the loosestrife with minimum impact on the cattail community. This is an example of selective weed control by herbicide placement.

Herbicide formulation can also affect the selectivity of foliar-applied herbicides by increasing the herbicides' ability to enter the plant. Adjuvants may be added to one formulation by the manufacturer and not to another. This additive can increase a herbicide's ability to pass through the cuticle (the waxy coating on leaves) or aid in by-passing leaf hairs by reducing surface tension.

Selectivity can be affected by the amount of herbicide applied. For example, low doses of certain herbicides may selectively control exotic species while inflicting only minimal damage upon native species. The salt of endothall has been used at very low rates for the control of curly-leaf pondweed, and 2,4-D used at low rates has effectively controlled Eurasian watermilfoil with little or no impact on nontarget species. Higher rates of the same herbicide may control a much broader range of plant species.

For a herbicide to be effective, it must first contact or enter the plant tissue. Morphological characteristics such as thick cuticles, waxy coatings or hairs can affect a plant's susceptibility to herbicides by physically preventing entry of the herbicide into the plant. Likewise, leaf shape and angle can affect the entrance of herbicide into the plant. Broad, horizontally oriented leaves will intercept and retain a greater amount of herbicide than narrow, upright leaves such as those of grasses and cattails.

A herbicide must be absorbed directly into cells or move through the plant (translocated) to the site where it is active. Herbicides may be bound on the outside of some plants or bound immediately after they enter the plant so that they cannot move to their site of activity. Some herbicides affect very specific biochemical pathways in plants. Therefore, they may be selective against a particular group or groups of plants because they are the only ones that have that particular pathway.

Growth stage can affect susceptibility in several ways. Young, actively growing annual plants that have not developed a cuticle or leaf hairs are more susceptible than mature plants to foliar-applied herbicides. The physiology of perennial plants changes during an annual growth cycle. During early stages of growth when upward transport of food reserves and other plant compounds is rapid, soil-active herbicides are readily absorbed and moved upward to the growing points and sites of herbicide activity. Conversely, foliar-active herbicides (e.g., glyphosate) are least effective during this time, allowing some plants to tolerate the treatment.

During late and postflowering periods, perennial plants are completing that year's growth cycle. At this time, they are translocating materials downward to the roots and are most susceptible to foliar-active herbicides, which move downward to the roots with the plant materials.

Lastly, certain plant parts may be susceptible to a herbicide while other parts of the same plant are not affected.

Environmental Factors that Affect Herbicide Application

Weather conditions, water movement, soil chemistry and water chemistry can greatly affect the success of aquatic herbicide applications. The applicator has little or no control over some of these factors but can control or compensate for some others. See Table 7-2 for environmental factors that affect aquatic herbicide application.

Weather Conditions

Rainfall

The most obvious effect of rainfall on a herbicide application is to wash foliar-applied herbicides off the emergent plant before they can be adequately absorbed. This is a particular problem with slowly absorbed systemic herbicides such as glyphosate. It is also possible that rain can enter a water body at a rate that dilutes a herbicide to an ineffective concentration. The applicator should be aware of potential weather conditions and should schedule applications accordingly.

Wind

Windy conditions can cause poor foliar application coverage. Wind can also indirectly affect the ability of leaves to absorb herbicides. Windy conditions favor herbicide drift, so applications should not be made when wind is strong enough to cause drift.

Wind can also affect the efficacy of herbicide applications for submersed plant management. As previously stated, the herbicide must be in contact with submersed plants at sufficient concentrations for sufficient periods of time to achieve control. Wind can affect the efficacy of submersed weed control applications by causing water movement that carries the herbicide away from the target plant. Avoid windy conditions when making herbicide applications.

Weather Conditions
Rainfall
Wind
Temperature
Water Movement
Soil Chemistry
Water Chemistry
pH
Turbidity
Hardness

Table 7-2. Environmental factors that affect aquatic herbicide application.

Temperature

Low temperature affects herbicide efficacy indirectly by affecting plant growth. At less than optimum temperatures plant growth slows down, and this may decrease herbicide absorption and activity. It has been suggested that temperature gradients within the water column have been a primary factor in the exchange of water between the shallow and open water regions of lakes.

Water movement

Most herbicides used for submersed aquatic weed management must be absorbed from the water into the target plants. A sufficient amount of herbicide must be available in the water long enough for the herbicide to be effective. It is difficult to manage submersed aquatic weeds in rapidly flowing water where the herbicide is carried away from the plants with the water flow. Special techniques must be used even in slow-moving water.

Methods used when managing aquatic weeds in flowing water include:

1. Use of trailing hoses to aid sinking the herbicide and adhering it to the plants.

2. Use of special herbicide formulations for flowing water, such as slow-release pellets.

3. Use of rapidly absorbed herbicides.

4. Use of sequential applications or injection equipment to increase contact time.

Water chemistry

Aspects of water chemistry that affect herbicide efficacy include pH, turbidity and hardness. The applicator has little control over these conditions in lake water. However, the applicator can decide which herbicide to use or adjust the rate of application according to conditions. More importantly, the chemistry of dilution water can affect herbicide performance and the applicator can sometimes make adjustments for this.

A pH measurement indicates whether something is acidic or basic. The pH scale goes from 0 to 14, and 7 is neutral. Values below 7 indicate acidic conditions and values above 7 indicate basic (alkaline) conditions. The pH of water can affect the rate at which plants absorb some herbicides. Knowing how the herbicide you are using reacts in a given pH range will help you select the appropriate rate to use. Some herbicides have increased activity in acidic waters, so you can use lower rates to obtain successful control.

Turbidity

Particles suspended in the water affect the water's ability to transmit light. This is called turbidity. The particles can be biotic (plankton), organic or inorganic (clay, minerals). Organic or clay particles are of most concern to the applicator because they can inactivate herbicides by binding to them. You should be careful not to increase turbidity by disturbing the lake or pond bottom with the boat. Particulates in diluent water can also affect herbicide performance and even render chemicals ineffective. Always use diluent water that is as clean as possible and be careful to keep the suction end of a filler hose far enough from the lake bottom to avoid drawing in sediments.

Hardness

As discussed previously, water hardness is a factor of dissolved calcium, magnesium, iron and strontium. Knowledge of water hardness is important to the aquatic pest manager because it can have important effects on herbicide performance and environmental considerations.

Certain herbicides can react with hardness components in water. This may cause them to become inactive or precipitate (come out of solution). This can happen either in lake water or in the spray tank. Consult with your chemical representative for details specific to each pesticide product. If possible, using softened or distilled water might aid in the efficacy of certain treatments — glyphosate applications, in particular.

The herbicidal properties of copper are very sensitive to hardness compounds in water. Inorganic copper algaecides are much more potent in soft water (<50 ppm calcium carbonate). Application rates must be adjusted downward accordingly to avoid nontarget impacts, especially to fish. When using copper in hard water, chelated forms of copper are much more effective because they stay in solution longer, are more readily absorbed by plants and are less toxic to fish.

Water chemistry is an important factor in the performance of herbicide applications. You have some influence over some of these factors, especially the source of diluent water for tank mixes. Take the following precautions when obtaining water for tank mixes:

a. Use the cleanest water available. Avoid sediments.

b. When tank mixing herbicides that are known to be inactivated by hard water, use the softest water available. If possible, use softened or distilled water; lake water is the next best choice. Avoid using well water.

c. Minimize the amount of time that herbicides remain mixed in tanks.

d. Read the label for special precautions or instructions.

Effects on Fish and Other Organisms

When used properly, aquatic herbicides are not toxic to fish, birds or other aquatic organisms. They are also short lived in the environment and do not accumulate in organisms. Under certain circumstances, however, fish kills can occur as a direct or indirect result of aquatic herbicide applications.

Fish kills are likely to occur as a direct effect of herbicide application only if a herbicide formulation known to be toxic to fish is applied in an enclosed water body. This type of herbicide should never be used where fish cannot escape toxic concentrations. When coves are treated, application should begin near shore to give fish an opportunity to escape. Most aquatic herbicides have very low toxicity to fish, and the concentrations that occur after application of recommended rates is far below concentrations that are toxic to fish. Rates of copper sulfate recommended for difficult-to-control filamentous algae can be toxic to fish in enclosed ponds, however, and care should be taken when making this type of application.

The most common reason for fish kills due to aquatic herbicide application is the indirect effect of lowered dissolved oxygen (D.O.) in the water. When performing any herbicide treatment, it is vital to limit the amount of vegetation killed at any one time. When a herbicide application kills large amounts of aquatic vegetation, the decaying vegetation and lack of oxygen production may cause D.O. to become so low that fish cannot survive in the water. If a herbicide that is effective on higher plants is used, and phytoplankton is present, the potential for a fish kill is reduced because the phytoplankton will continue to produce oxygen. Review the product label statements — they may limit the percentage of the lake area treated during one application. See Table 7-3 for effects of dissolved oxygen on warm-water pond fish.

The danger of fish kills is less in cooler water because it can hold more oxygen than warm water. For example, oxygen-saturated water at 65° F contains 9.2 parts per million oxygen, whereas water at 85° F contains only 7.5 parts per million oxygen.

To minimize the potential of fish kills, avoid herbicide applications to large areas of weeds, to warm water, during prolonged periods of cloudiness and in areas where fish movement is restricted. Manage large weed populations by a series of applications to portions of the water body, and/or treat during the spring when water temperatures are lower. As a rule, do not treat more than 30 to 50 percent of the surface area of any body of water at one time. If more than 50 percent needs treatment, treat only one-third to one-half of the area at any one time. Follow that with a second application two to three weeks later.

Herbicide-related fish kills, either direct or indirect, are not likely to occur as a result of partial area applications in large water bodies because if they can, fish will move to other parts of a lake to avoid adverse conditions. Nevertheless, take all precautions to avoid conditions that could lead to fish kills when applying aquatic herbicides.

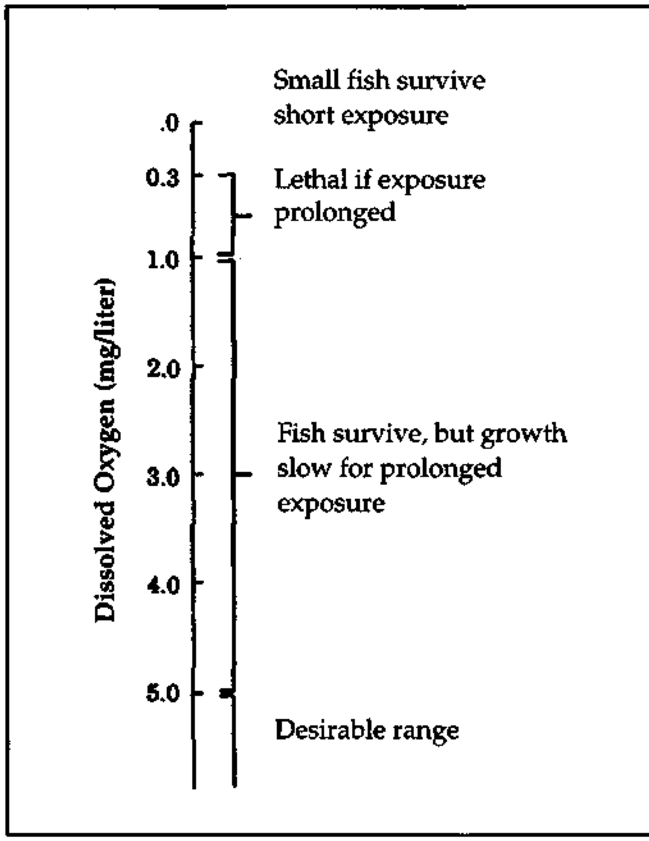


Table 7-1. Effects of dissolved oxygen on warm-water pond fish.

Water Use Restrictions

The introduction of most aquatic herbicides into an aquatic environment requires restricting the use of the water until the herbicide has degraded, become inactivated or dissipated. Consequently, determining the present and potential uses of a body of water is one of the most critical steps in choosing an aquatic herbicide.

Restrictions on water use after a pesticide treatment are imposed for several reasons. Based upon data required for pesticide registration, residue tolerances, residue data and environmental fate, water use restrictions or precautions for drinking, swimming, fishing, irrigation, watering livestock and domestic uses may be placed on the label. This process ensures that the public will not come in contact with a herbicide at potentially harmful concentrations.

Water use restrictions also prevent people from disturbing the lake water and sediments which could reduce the effectiveness of the treatment. Compounds must be absorbed by the plants in large enough quantities to kill them. If swimmers enter the treated area before the plants absorb enough of the active ingredient, the sediment that they kick up may bind with the herbicide and render a treatment ineffective.

The period of restriction, which varies among herbicides, depends on the dosage and the persistence of the compound in the water. Some restrictions extend for only a few days, others may last for 12 months.

Other herbicide restrictions involve the type of water body to be treated. In many cases, a herbicide is restricted to a certain type of site, such as a pond (vs. a lake), an irrigation canal (vs. a drainage ditch), a ditch-bank (vs. a drainage ditch), a ditch-bank (vs. open water treatment), or non-flowing (vs. flowing) water.

Consult the Michigan Department of Agriculture and MDNR regarding restrictions that may not be noted on the herbicide label. Restrictions are usually imposed for streams, public or multiple-use lakes, and reservoirs. Always consult herbicide labels and state agencies for detailed information.

Algaecides

Chemicals used to control algae are known as algaecides. Timing their application to obtain desirable results is critical. Treat with copper compounds on bright, sunny days when the algae are actively functioning and releasing oxygen. Early in algal bloom development, the algae may be dispersed throughout the water, whereas later the bloom may form a surface scum. Low concentrations of chemicals can be used to thin the algal populations during development. After a scum forms, treating only the upper 2 feet of the water with an algaecide is required. When treating algal scum, calculate the amount of chemical for the upper 2 feet, and spray it on the water surface or inject it just beneath the surface. This method can be used only with copper compounds. Because a rapid kill of algae can cause oxygen depletion, early season treatment when waters are cool and well oxygenated and algal populations are low is preferable to later treatments.

If treatment of attached algae is needed and the growth is underwater, the algaecide should be dispersed in the water. If mats of attached algae are floating, at least some of the compound should be dissolved in water and sprayed directly on the mats. Algaecides containing copper must come in direct contact with the algal cells to be effective.

Pesticide Fate

Aquatic pesticides have many potential fates. The most desirable fate is *absorption* by the target pest. If plants are your target pest, pesticides can be absorbed by the leaves, stems, flowers or roots. Generally, if they're not absorbed, the compounds will naturally degrade, either by *microbial action* (bacteria and fungi), *chemically* (reaction with water and other molecules) or *photochemically* (sunlight), or by being chemically bound to sediments (adsorbed) and then broken down.

Microbial degradation (or *biodegradation*) is mediated by microorganisms that either change the compound into something else (*biotransformation*) or actually break it down to its elemental components. Biotransformation can change the original compound into one of either lower or higher toxicity.

Chemical degradation can occur through many pathways, the most common of which is oxidation (adding oxygen). Photochemical degradation, or *photolysis*, can also transform or degrade a pesticide. The process involves sunlight, either through direct interaction with the pesticide, or indirectly by sensitizing another compound that degrades the pesticide through the process of energy transfer. Adsorption is the process by which the pesticide is physically and/or chemically bound to soil particles. This occurs most frequently in soils with high organic matter content.

Once it's adsorbed to particulate matter or sediments, the pesticide can be broken down by one of the processes described above, either while still bound to the soil particles or after being released (*desorbed*). Adsorption to bottom sediments causes a herbicide to be unavailable. This is undesirable if toxic concentrations to the target plant were not reached or retained long enough for an effective treatment.

Other undesirable fates of pesticides remove or lessen the amount of pesticide available for the intended purpose. *Drift*, through the movement of water or wind during application, can not only lessen the amount available but can potentially harm nontarget areas and species. Applicators are liable for damage caused by drift to nontarget sites. Some pesticides are *volatile*. The more volatile a substance is, the more likely it is to have vapors associated with it as it evaporates. Few aquatic herbicides are volatile.

Timing of Treatmemt

Most aquatic herbicides are applied in mid- to late spring or early summer when the plants are young and growing vigorously and before they have gone to seed. Herbicide penetration and translocation are usually greatest before plants reach maturity. Not only are the weeds more susceptible at this stage, but there are fewer weeds to treat than there will be later in the season.

Another reason for early season treatment is that cool water contains more oxygen than warm water and so provides a greater margin of safety for fish. Most aquatic herbicides should not be applied when the water is too cold (below 60°F), however. Though plants grow at these temperatures, they may not be metabolizing rapidly enough to take in sufficient quantities of herbicide for the herbicide to be effective. Treatment should also be delayed when there is a chance that heavy spring rains will wash the herbicide out of the target area or off the target plant. Consult your label for specific restrictions.

Except when preemergence herbicides are being used, plant growth should generally be visible at the time of treatment. Evidence indicates that autumn treatments of some species of submersed weeds are effective. For most species, however, plants have produced by fall seeds or algal spores, from which new plants will grow the following season.

Chapter 7 – Herbicide Technology and Application Considerations Review Questions

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

1. Which statement regarding aquatic herbicides is false?
   a. Their formulation consists of an organic or inorganic active ingredient, an inert carrier and perhaps adjuvants.
   b. Every herbicide must be registered for use in the United States by the Environmental Protection Agency.
   c. About 200 herbicides are registered for use on aquatic sites in Michigan.
   d. None of the above.

2. List seven of the considerations in planning a successful aquatic herbicide program.
   1.
   2.
   3.
   4.
   5.
   6.
   7.

3. Contact herbicides are generally more effective on perennial and woody plants than on annual herbaceous plants. True or False?

4. Explain the differences between a contact herbicide and a systemic herbicide.

5. When are herbicides that affect cell division most effective?
   a. When the plant has reached full maturity.
   b. During the plant's early growth period.
   c. Before the weed seed germinates and begins to grow.
   d. Both a and b.
   e. Both b and c.

6. A herbicide that causes abnormal plant tissue development is a
   ______________________________.

7. Which is an example of a herbicide that is used to control all or most vegetation?
   a. PGR
   b. Broad spectrum herbicides
   c. Selective herbicides
   d. Both a and c.

8. Which will intercept and retain a greater amount of herbicide?
   a. Narrow, upright leaves.
   b. Broad, horizontally oriented leaves.

9. Which statement about environmental factors affecting herbicide applications is false?
   a. Washing foliar-applied herbicides off the plant before they can be fully absorbed is the most obvious effect of rainfall.
   b. Windy conditions can affect the efficacy of submersed weed control by causing water movement.
   c. High temperatures cause the plant to decrease herbicide absorption and activity.
   d. Applications should not be made when the wind is strong enough to cause drift.

10. The condition that occurs when particles suspended in the water affect the water's ability to transmit light is called______________.

11. The introduction of most aquatic herbicides into an aquatic environment requires restricting the use of the water until the herbicide has:
    1.
    2.
    3.

CHAPTER 8

AQUATIC HERBICIDE APPLICATION EQUIPMENT AND TECHNIQUES

When a management plan has been established for a body of water, efforts can begin to obtain and maintain the aquatic qualities outlined in the plan. Fulfilling a management plan is an ongoing process involving several pest management techniques.

This chapter focuses on the various pesticide application methods used for managing aquatic weeds.

Application Methods

After identifying the pest and selecting the correct pesticide for treating aquatic plants, choosing the appropriate application technique is the next important step influencing a chemical's effectiveness in controlling the aquatic weed population. Choice of application techniques should be based on the type of aquatic weed problem that exists and the herbicide to be used.

Aquatic herbicides are formulated as liquids, powders and granules. The liquids and powders are usually applied in a water carrier; granules are applied directly to the water. Invert emulsion systems for control of submersed weeds are used to improve herbicide placement in other states but are not permitted in Michigan. Large bodies of water may require aerial spraying. Some swimmer's itch treatments are done this way in Michigan.

Bottom Treatments

Herbicides can be injected into bottom water by connecting weighted brass pipes to 15- to 30-foot hoses that extend from a boom on the spray boat. The herbicide is released into the water through small holes bored about 6 inches from the end of the pipe. For best results, pipes should be no more than 3 feet apart. Application rates are based on the volume of the lower 2 feet of water. This technique is particularly effective early in the growing season when submersed plants are still short. It works best in lakes or static waters that have firm, sandy bottoms; it is not recommended for flowing water or muddy bottoms.

Bottom treatments using weighted invert emulsions or polymers are not currently permitted in Michigan.

Granular Treatments

Granular herbicides should be applied with a granule spreader, not by hand. These products sink to the bottom and release the herbicide into the water. The inert ingredient, or the carrier of the active ingredients in granular formulations, is typically clay. Deposition of this clay on the lake bottom which may not be desirable.

Spray Treatments

Plants with most of their leaf area above the water surface (emergent, free-floating and rooted floating plants) are usually sprayed with aqueous solutions of herbicides. A wetting agent enhances the chemical's penetration of the cuticle, the thin, waxy layer on leaf surfaces. The dosage of foliar applications is calculated on the basis of the surface area to be covered.

Treatment of Water Conveyance Systems

Making applications to flowing water systems requires permission from every riparian along the entire system to be treated. Flowing water in ditches and canals requires control techniques different from those used in lakes, ponds or other static systems. Herbicide solutions are usually injected or allowed to drip into the water, and the water disperses the herbicide. In drip systems, constant-flow metering devices slowly drip the chemical into the water. The dosage rate on the herbicide label is usually given as the amount of herbicide per hour per cubic feet per second (CFS). CFS can be determined using the following formula:

CFS = average width (ft) x average depth (ft) x velocity (ft/sec) x 0.9

The number 0.9 is a correction factor for the velocity measurement. The velocity measurement is taken at the surface, and this factor helps average the measurement throughout the depth of the water.

A dry concentrate applied in large volumes can be used to "slug" or introduce high concentrations of a chemical into the water. The concentration gradually decreases downstream, providing control and permitting the safe use of the water. This procedure is commonly used with copper for algae control.

Re-treatment

Most aquatic herbicides are contact materials. Contact herbicides often control aquatic plants for three to six weeks depending on the growing season. Most aquatic contact herbicides are not persistent (ability of a pesticide to remain in an active form at the site of application or in the environment). This characteristic can be desirable because it means that restriction periods on the use of water can be fairly short. Limited persistence can also be undesirable because vegetation can regrow in an area soon after treatment, either from vegetation not killed by the treatment or vegetation that comes back from seeds, spores, root crowns, turions or tubers. This problem is particularly true of algae.

Algae must often be re-treated several times per season, whereas flowering plants usually require only a follow-up treatment to kill missed or late-sprouting plants. A common weed "shift" is the appearance of Chara after submersed flowering plants are controlled. Another is the bloom of microscopic algae after submersed plants are killed. This requires the area to be re-treated, targeting a different plant. Although weed shifting is common, it is not the rule.

Re-treatment of a given site is typical during a single growing season. However, the species targeted with subsequent applications are not necessarily the same as those targeted by the initial treatment. Rather, subsequent or sequential applications are targeted at plant species that have emerged since the initial treatment. Applications may continue during the growing season as different weed species emerge.

Re-treatment in subsequent years is usually required because new species appear or weeds return from seeds, spores or vegetative propagules. A successful herbicide weed control program should be considered a long-term program requiring continued but varying treatments.

Equipment Selection

Most equipment used for aquatic herbicide applications is similar to that used in agricultural applications. Modifications are made to adapt equipment to special situations, such as applying from boats and injecting herbicides into deep water. The remainder of this chapter discusses the use of conventional herbicide application equipment and adaptations for use with aquatic herbicides.

Liquid Formulations

The majority of aquatic herbicides are formulated as liquids. The equipment needed for applying liquids depends on which of the two methods below is used:

a. Spray tank. The herbicide and the diluent — usually water — are mixed in a tank and the mixture is applied to the weeds.

b. Direct metering into pump suction. The herbicide is metered into the suction side of the pump at the rate needed to apply the correct amount per acre. The diluent needed to ensure adequate coverage is drawn directly from the body of water being treated.

The spray tank method is suitable for treating relatively small areas or when mixing several herbicides. When large areas are treated, it may be more efficient to use the direct metering method to reduce the time spent refilling the tank.

Aquatic plants are treated from boats with out- or inboard engines, airboats, fixed-wing aircraft and helicopters. The type of application equipment used is dictated to some degree by which vehicle is used.

Spray Tank Applications

Figure 8-1 shows a typical sprayer used to apply herbicides from a boat. Features of the sprayer components are described below.

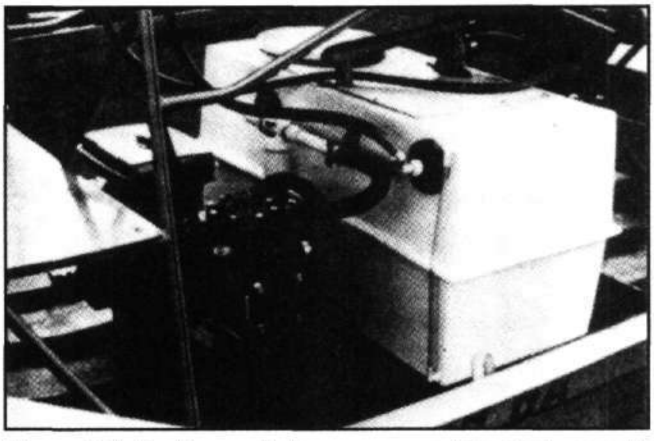


Figure 8-1. Boat mounted sprayer used to apply aquatic herbicides.

Tank. The boat-mounted tank, usually made of fiberglass, holds 50 to 100 gallons. Usually the tank will have graduations on the side that indicate volume. The tank should have a large opening for easy filling and cleaning.

Agitation system. Most spray tanks are equipped with some type of agitation system. **Good agitation is important for maintaining a uniform spray mixture and for mixing adjuvants such as inverting oil or polymers.** Figure 8-2 shows hydraulic and mechanical agitators. Some tanks are equipped with both types of agitators.

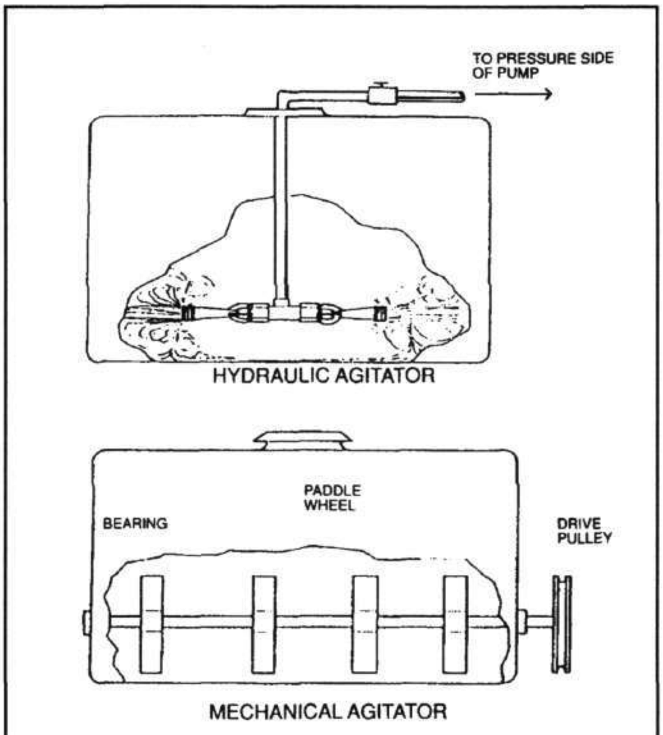


Figure 8-2. Agitation systems for liquid application equipment.

A well designed hydraulic agitation system that uses a venturi device for stirring is adequate for keeping wettable powders in suspension. However, this type of agitator will not stir the mixture enough to form invert emulsions or mix polymers. To function properly, the hydraulic agitation line must be tapped into the high-pressure side of the pump (Figure 8-2). When you're using a hydraulic agitator, the pump must have the capacity to deliver the required flow simultaneously to the boom or handgun and to the agitator. If the maximum pressure that can be achieved after completely closing off the pressure regulator is lower than the pressure needed, the agitator orifice size must be reduced. Mechanical or paddle wheel agitators are probably the best type of agitator. Well designed mechanical agitators stir the mixture vigorously and allow the use of both polymers and invert emulsions in states that permit these applications. Sometimes a clutch is added to the agitator drive, and the operator can keep the mixture at the desired consistency by agitating only when needed.

Hoses. The inner and outer layers of all hoses should be resistant to the chemicals used. Check with the chemical and hose supplier if there is any doubt — a hose weakened by chemicals might leak or burst unexpectedly. Two materials widely used for hoses are ethylene vinyl acetate (EVA) and ethylene propylene dione monomer (EPDM). A pressure hose must be strong enough to withstand the maximum pressure within its length without bursting. Pressure varies along the hose, with the greatest pressure occurring at the pump. Hose size is important because the pressure loss in the hose depends on the hose inside diameter (ID), length and flow rate (Figure 8-3). For example, a 1/2-inch ID hose loses 1 pound per square inch (psi) per foot at a flow rate of 10 gallons per minute.

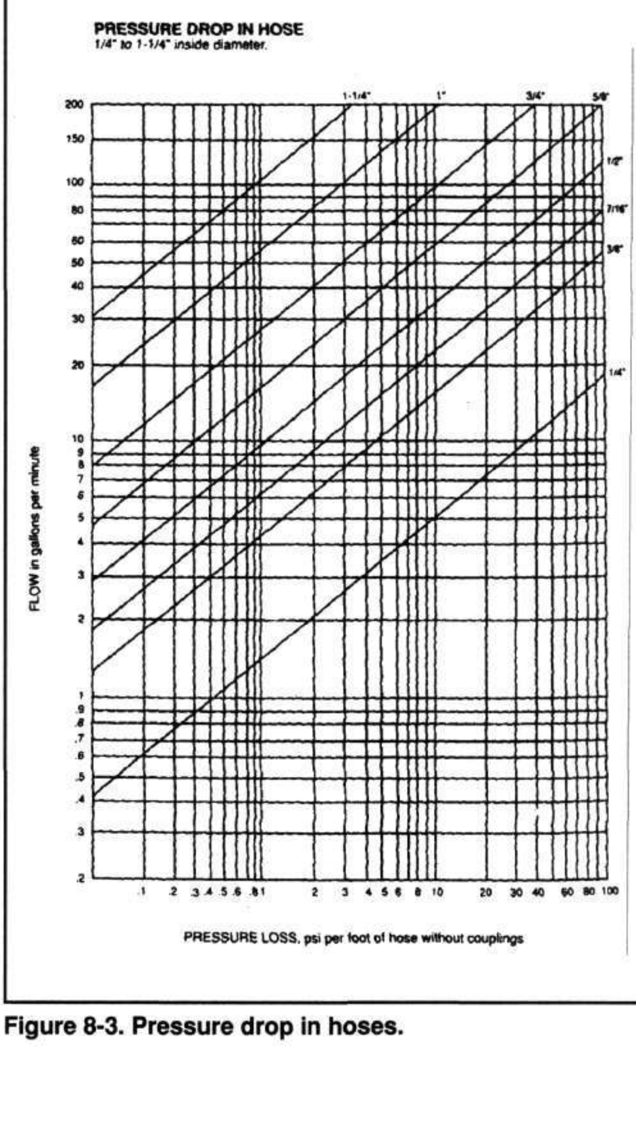


Figure 8-3. Pressure drop in hoses.

Pressure loss in relatively short hoses is not very important, but it is important to choose the proper hose size when extremely long hoses are used, such as in some handgun spraying work. Recommendations for hose sizes are presented in Table 8-1.

Suction hoses are under a partial vacuum — they will not burst but they can collapse. Choose a suction hose that is reinforced to prevent collapsing. A collapsed suction hose can restrict the flow of liquid and starve a pump. This will cause decreased outflow and greatly accelerated wear. As a rule of thumb, suction hose diameters should be at least as large as the pump inlet port.

Polyvinyl chloride (PVC) pipe works well for rigid plumbing, but you need to use caution in selecting valves. For example, a 1 inch valve can be plumbed to a 1 inch pipe, but the inside diameter of the valve may be restricted to 1/2 inch.

Pumps. Most pumps used for applying liquid herbicide formulations are of five general types: roller, piston, centrifugal, diaphragm and gear. Each type has certain capabilities and limitations that determine when it should be chosen. Characteristics of the various pumps are listed in Table 8-2.

Roller pumps have the advantage of being relatively inexpensive. They are widely used in agriculture on general-purpose crop sprayers. Roller pumps are not often used for aquatic weed control work, however, because they do not produce the high pressures needed for handgun spraying. Though a pressure capability of 300 psi is stated for a roller pump (see Table 8-2) which is adequate for handgun spraying, the pump would not be able to sustain high pressure very long because the rollers wear and fluid leaks back past the rollers. Figure 8-4 shows how to plumb a liquid application system using a roller pump. The system has a hydraulic agitator that would be suitable only for systems not used to apply invert emulsions or sprays containing polymers.

Piston pumps are often used in aquatic weed control because they can deliver high pressure for handgun spraying. These pumps are dependable, long-lived and highly adaptable to most types of service. Their primary disadvantages are that they are expensive and they deliver relatively low volumes, though the volume is usually sufficient for aquatic applications.

A piston pump is a positive displacement pump. This means that the output depends on the displacement of the piston in the cylinder. Output is proportional to speed and virtually independent of the pressure needed to force the flow through the orifice area on the system.

Output from a piston pump is not steady. It comes in spurts because the distance that the piston travels in the pump cylinder varies with time.

	Hose size (inches)	
Pump output (gpm)	Suction side	Pressure side
< 12	3/4	5/8
12-25	1	3/4
26-50	1 1/4	1

Table 8-1. Recommendations for hose sizes.

Pump type	Capacity (gpm)	Speed (rpm)	Maximum pressure (psi)	Material that can be sprayed
Roller	0-35	600-2600	300	Nonabrasive
Piston	0-60	500-1800	1000	Abrasive
Centrifugal	0-150	600-6000	70	Abrasive
Diaphragm	1-60	200-1200	850	Abrasive
Gear	5-20	500-1800	100+	Nonabrasive

Table 8-2. Characteristics of various pumps.

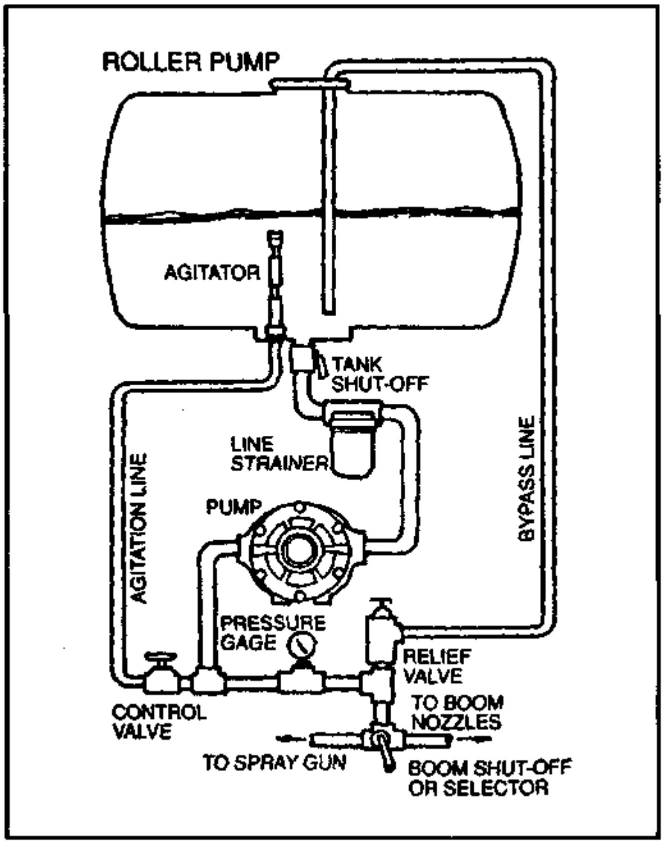


Figure 8-4. Roller pump system.

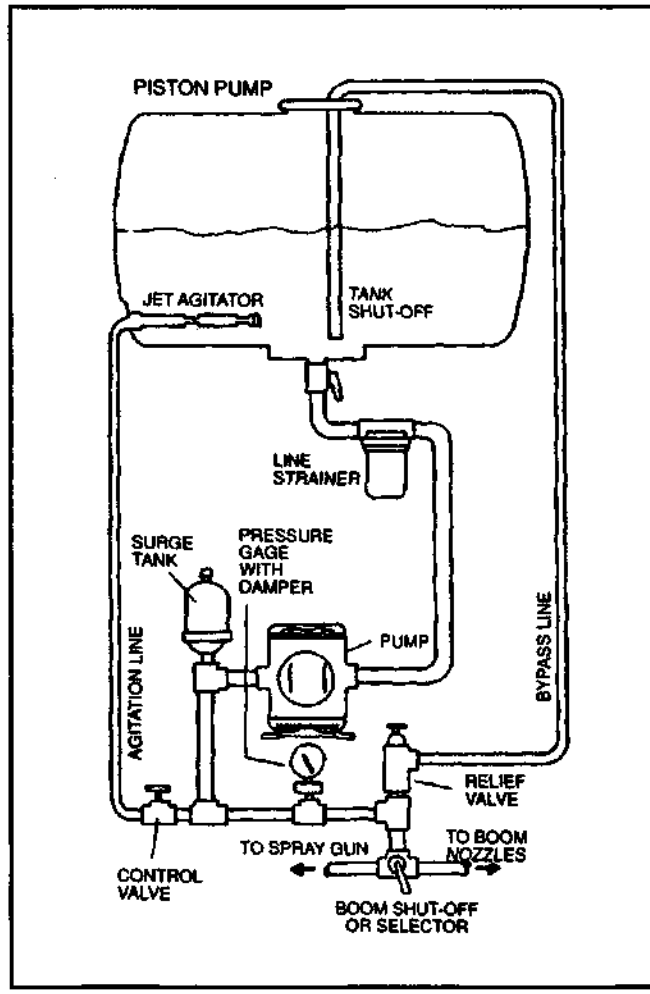


Figure 8-5. Piston pump system.

This problem can be eliminated through the use of a surge dampener. Pulsation is especially noticeable for pumps with a small number of pistons (small pumps often have two pistons). The pulsing nature of the flow makes a surge tank desirable. The system should also be equipped with a glycerine-filled pressure gauge (glycerine dampens movement of the gauge needle). These gauges last longer and can be read more easily than non-dampened gauges on piston pump-equipped systems.

Figure 8-5 shows how to plumb a system equipped with a piston pump. The system includes an unloader valve that is especially useful when spraying with a handgun. When the gun is shut off, the system pressure rises until it is sufficient to overcome the spring force on the unloader valve. The valve will crack open and bypass fluid back to the tank. Without the unloader valve, the pressure would continue to rise until a hose burst. The plumbing system shown in Figure 8-5 is appropriate for all of the positive displacement pumps, including diaphragm and gear pumps, as well as the piston type.

Centrifugal pumps deliver high flow rates when working against a low pressure. These pumps are especially useful for transferring fluids from one tank to another or from the body of water into the tank when refilling.

Diaphragm pumps are now used in many applications instead of piston pumps. Benefits of diaphragm pumps include relatively low cost, low maintenance and small size compared with other pumps with similar flow and pressure ratings. Like piston pumps, diaphragm pumps are positive displacement pumps, so the pump output depends on pump speed and remains constant regardless of the pressure it is working against.

Gear pumps are used in a number of applications and are positive displacement pumps capable of high pressure. The corrosive chemical comes in contact with the pumping gears, so maintenance can be a problem. Gear pumps are becoming less popular and are being replaced by diaphragm and piston pumps in many installations.

Nozzles. The spray nozzle forms the spray pattern, determines the droplet size and meters the flow rate. Nozzle selection is based on a balance of these three functions. Many types of nozzles are used in terrestrial weed control. Because of the nature of aquatic weed control, the variety of nozzles used in aquatic spraying is much narrower.

The method of application (submersed or surface) determines the nozzle type selected. The four primary application methods and nozzle considerations in aquatic weed control are:

1. Handgun spraying of surface, emersed and ditch bank species. Handguns are equipped with nozzles that provide a high flow rate (3 to 6 gallons/minute), a straight stream and a large droplet size. This arrangement ensures thorough wetting of the target vegetation with minimum spray drift.

2. Subsurface injection just below the water surface for submersed weed control. Usually short hoses are spaced at approximately 2 foot intervals on a short bow- or stern-mounted boom. Hoses are just long enough to place the nozzle at the water surface or just below it (Figure 8-6). The nozzle body contains a disk that meters the flow into the water.

3. Bottom placement or deep-water injection: Nozzles are located at the ends of long hoses that trail from a boom on the bow of the boat. Hoses are usually weighted to keep the herbicide placement deep within the weed mat or near the bottom (Figure 8-7). A common arrangement involves constructing a nozzle by drilling small holes in a piece of galvanized pipe. The length of the pipe depends on how much weight is needed to lower the hose to the desired depth. Pipe length varies from 9 to 30 inches. The pipe is capped on one end and attached to the hose on the other. Deep-water injection hoses must not have any clamps or protrusions that will catch and hold plants.

4. Aerial applications: Aerial applications normally use hollow cone or flat fan nozzles to improve coverage with the smaller volume of spray solution applied per acre. A specialized aerial boom designed to produce large droplets at low pressure and low volume is the microfoil boom (Figure 8-8).

Figure 8-6. Subsurface injection just below the water surface for submersed weed control. If lake water is stratified, reduced control may result with this type of application.

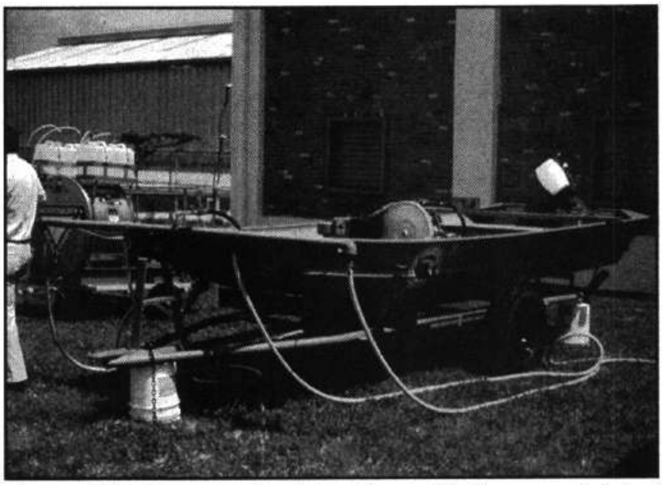


Figure 8-7. Deep water injection with long, weighted hoses can be used to overcome the effects of stratified water.

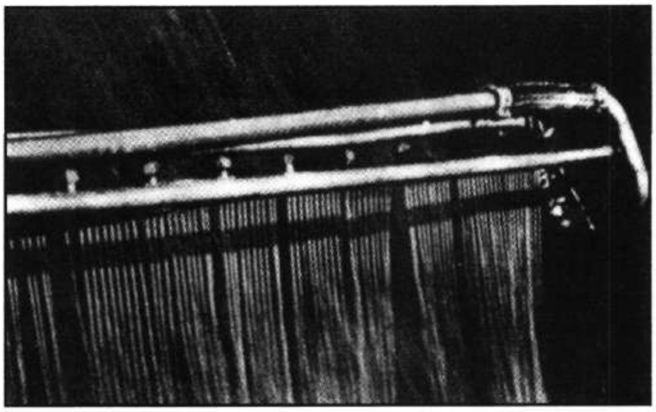


Figure 8-8. Microfoil booms are often used in aerial herbicide applications to reduce drift.

Direct Metering into Pump

When large areas are treated, it is often more efficient to meter the herbicide into the suction side of the pump and eliminate the time spent filling and mixing tanks. Water is drawn into the pump through "water boxes" built into the bottom of the spray boat (Figure 8-9). Normally, one or more plastic tubes are tapped into the pump suction line. Each tube has a valve for opening and closing the lines. Tubes have an in-line orifice used to meter the correct amount of herbicide into the system. Figure 8-10 shows how a typical herbicide withdrawal hose is constructed.

A number of suction hoses can be used so application can continue without interruption. When the herbicide in the container being used is depleted, the applicator opens a valve in the hose in a second container and closes the valve of the empty one.

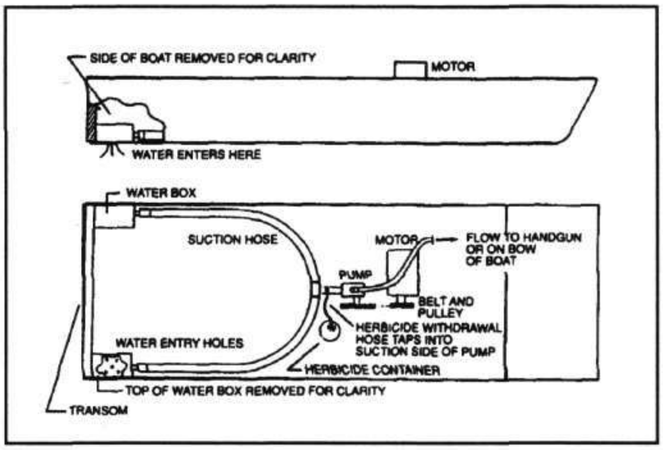


Figure 8-9. System for withdrawing herbicide directly from the container and water from the treated water body.

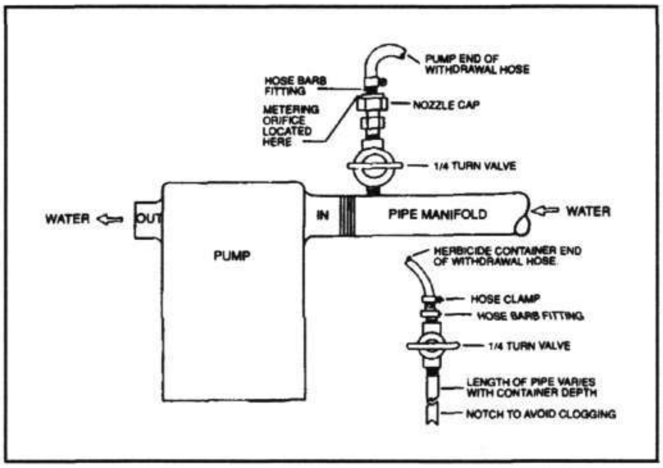


Figure 8-10. Plumbing detail of herbicide withdrawal hose.

Except for not using a tank and having the previously described equipment on the suction side of the pump, equipment used for spraying in this manner is very similar to tank-mix units.

Applying Sprays Containing Polymers

Polymers are long-chain carbon molecules which, when united with water, thicken the solution and increase the number of large droplets. They are often used when spraying surface weeds with a handgun. In Michigan, polymers may be used on emergent plants only.

Applicators may find that the output from their sprayers will diminish greatly when spraying with 1 to 2 percent polymer. The reason often given for the flow reduction is that the water-polymer mixture flows less readily, so the pump is unable to force the material through the nozzles. This is not the reason for the reduced flow, however.

The positive displacement pumps normally used in aquatic weed spraying can force any amount of material that enters the pump out of the pump. If the engine speed (rpm) is set by a governor (as are most small gas engines that power sprayer pumps used in aquatic weed spraying), the output will be the same for a viscous liquid as it would be for water, as long as the same amount entered the pump. The difference is that the pressure required to force the viscous liquid through the discharge hose would have to be greater. More pressure means the engine has to deliver more horsepower.

Output decreases when using these high concentrations (1-2%) of polymer because the amount entering the pump suction is reduced. Flow rates of water and water-polymer mixture through a given nozzle at a given pressure vary little. Most of the flow reduction occurs because the pump is starved on the suction side. A system used to apply water-polymer mixtures should have extra-large suction lines with a minimum of fittings between the tank and the pump inlet.

Granular Formulations

Granular herbicides are normally applied with a bow-mounted centrifugal or blower-type spreader (Figure 8-11). Centrifugal spreaders can treat a wide swath when relatively large granules are used. The ability to treat a wide swath (30 to 40 foot) without requiring any type of structure extending beyond the sides of the boat makes granular application attractive. The disadvantage

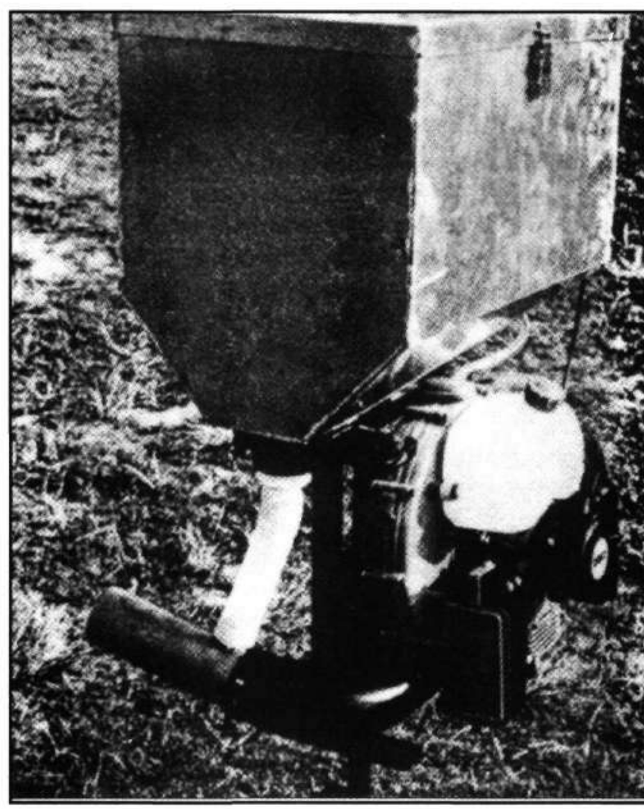


Figure 8-11. Blower type spreader for applying granular or pellet herbicide formulations.

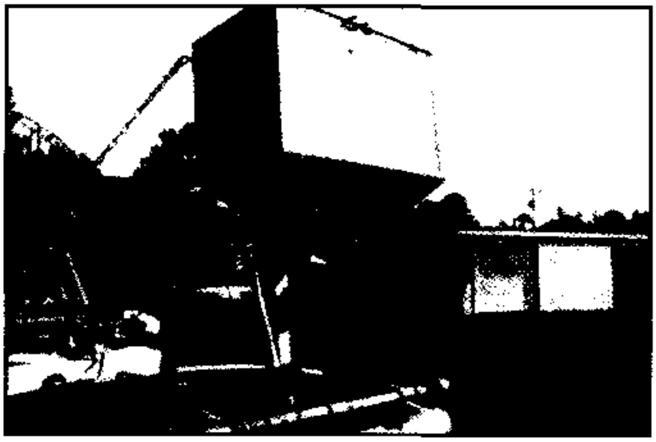


Figure 8-12. Centrifugal type spreader for applying granular or pellet herbicide formulations.

is the large quantity of material (20 to 400 pounds/acre) that must be handled. The rotor that slings the granules is driven by a 12-volt DC motor. Normally, the spreader is purchased as a complete unit except for the mounting system. Because boats used to treat aquatic weeds are normally used to apply both sprays and granular applications from the bow, the spreader is usually mounted so that it can be quickly removed.

Blower-type spreaders use air pressure generated by a low-pressure high-speed two-cycle blower, with a venturi discharge nozzle to propel the granules. An advantage of blower-type spreaders is that they create little dust compared to that created when the mechanical rotor of centrifugal spreaders strikes pellets or granules.

Chapter 8 – Aquatic Herbicide Application Equipment and Techniques Review Questions

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

1. After you've identified the pest and selected the correct pesticide for treating aquatic plants, the next important step influencing a chemical's effectiveness in controlling the aquatic weed population is the ______________________.

2. Which of the following application methods statements is incorrect?
   a. Granular herbicides should be applied by hand.
   b. Plants with most of their leaf area above the water surface are sprayed with aqueous solutions of herbicides.
   c. Applications to flowing water systems require control techniques different from those used in lakes, ponds or other static systems.
   d. In a flowing water system, the herbicide concentration gradually decreases downstream.

3. Algae requires only one follow-up treatment to kill missed or late-sprouting plants.

   True or False?

4. When large areas of a lake are treated for weed control, it may be more efficient to use the direct metering method for herbicide dilution.

   True or False?

5. Pressure loss in a hose does not depend on:
   a. Water content.
   b. Hose inside diameter.
   c. Hose length.
   d. Flow rate.

6. Name two materials widely used for hoses.

   1.

   2.

7. As a rule of thumb, suction hose diameters should be at least as large as the __________ __________ __________.

8. A centrifugal pump has a capacity of __________ gpm and a maximum pressure of ________psi.

9. Which statement concerning the uses of five general pump types is false?
   a. Roller pumps are widely used for aquatic weed control because of their high pressure.
   b. Piston pumps are used in aquatic weed control because they deliver high pressure for handgun spraying.
   c. Centrifugal pumps are useful for transferring fluids from one tank to another.
   d. Diaphragm pumps are positive displacement pumps so the pump output depends on pump speed and remains constant regardless of the pressure it is working against.
   e. In gear pumps, corrosive chemicals come in contact with pumping gears, so maintenance can be a problem.

10. When large water areas are treated, it is often more efficient to meter the herbicide into the suction side of the pump and eliminate the time spent filling and mixing tanks.

    True or False?

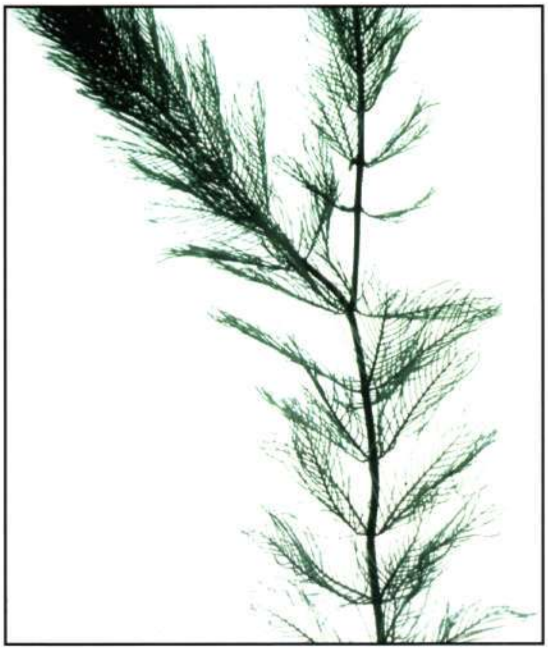
ALGAE

▲ **Planktonic algae** are microscopic plants usually suspended in the upper few feet of water. They often reach bloom proportions. Water appears pea soup green or brownish. Common genera include *Anabaena, Chlorella, Pediastrum, Scenedesmus,* and *Oocystis.*

▲ **Filamentous algae** are also known as "pond scum" because of greenish brown mats formed on the water's surface. Individual filaments are a series of cells joined end to end. This gives the thread- or cotton-like appearance. Common genera include: *Spirogyra, Cladophora, Rhizoclonium, Mougeotia, Zygnema* and *Hydrodictyon.*

SUBMERSED PLANTS

◀ **Eurasian watermilfoil** ▶ *(Myriophyllum spicatum)* appears brownish green to green, usually with some red on the stems. Leaves usually occur in whorls (clusters) of four or five, with 14 to 20 pairs of narrow, flat, dissected leaves that give them the appearance of weather-beaten feathers. Tiny reddish flowers are whorled in groups of four on the terminal stalk, which may or may not extend above the water. Plants may reach lengths of 10 ft (3m) or more. Plant stems and leaves may become calcified in hard water.



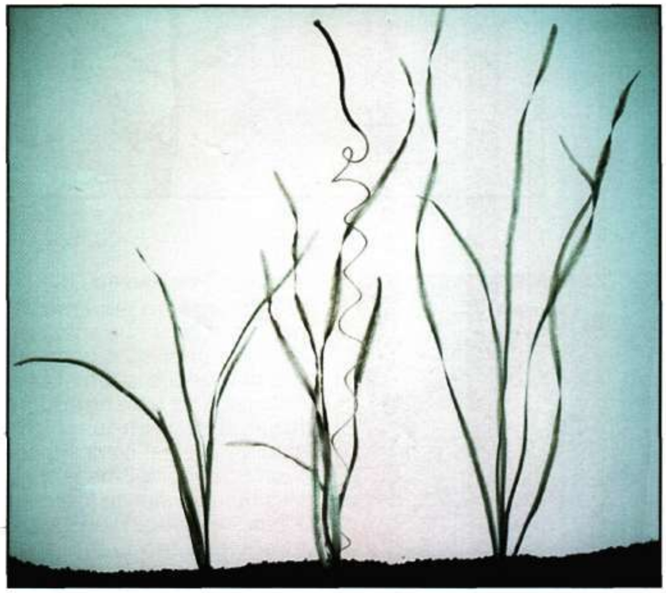
▲ **Curly-leaf pondweed** *(Potamogeton crispus)* has flattened, winged, red-brown, brittle stems growing up to 6 feet long. Leaves are long and narrow (linear) with visible veins and blunt tips. Leaf margins are finely but irregularly serrated (toothed) and wavy. Leaves are 1 to 4 inches long and less than a 1/2 inch wide and occur alternately along the stem. Flowers and fruits are borne in whorls of three to five on a spike above the water surface.

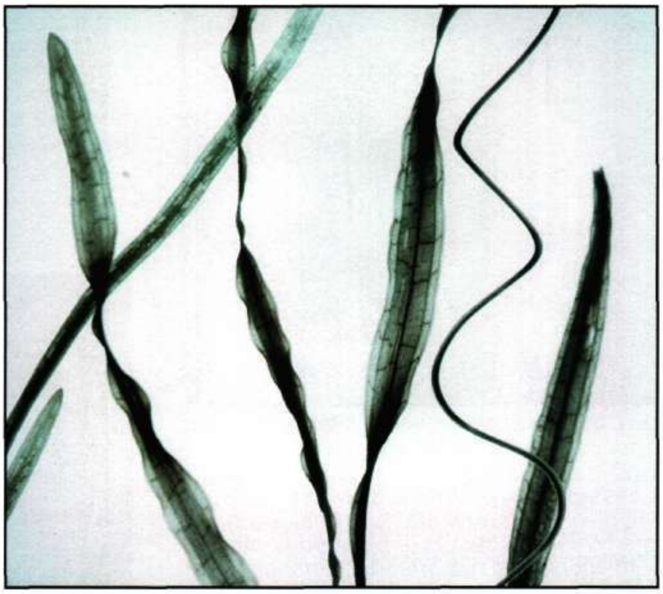
◀ **Sago Pondweed** *(Potamogeton pectinatus)* has slender, somewhat red, freely branched stems. All the leaves are submersed, filiform and arranged like fans at the ends of the stems. The leaf blades taper from base to tip, measuring less than an inch to just over 12 inches long. Leaves are nearly pointed at the apex and are alternately arranged on the stem. Small, nut-like fruits are arranged like beads on a string and emerge from the water.

▲ **Clasping-leaf pondweed** *(Potamogeton richardsonii)* has wide, waxy, wavy leaves. Each leaf has broad base that appears to extend three-quarters of the way around the stem. The upper stem is commonly branched and leafy. Leaves are arranged alternately on the stem and may be lanceolate to elliptical or ovate.

▲ **Brittle naiad** *(Najas minor)* (bushy naiad) has long, linear, pointed leaves with distinct spiny teeth along their edges. Leaves are submersed, arranged oppositely or in groups of more than two at the node, and concentrated at the tips of the stems.

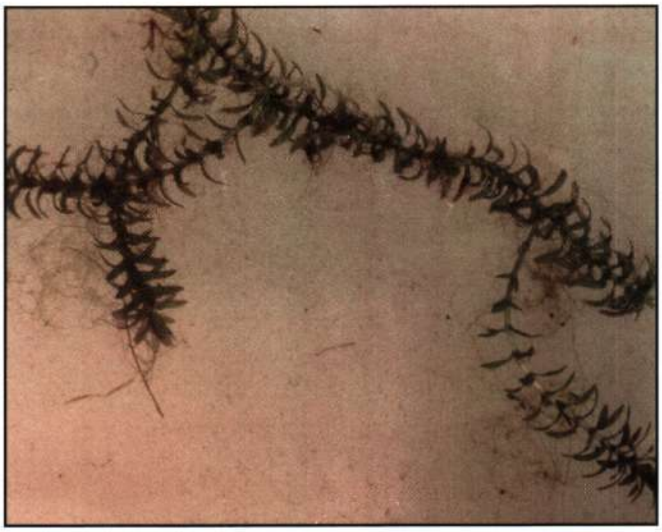
▲ **Southern naiad** *(Najas guadalupensis)* has reddish brown stems that are usually very leafy. The linear, flat leaves are wider at the base and arranged oppositely or in whorls of three on the stem. Leaf margins may have minute spines. The tiny seeds are concealed in the axils of the leaves.





▲ **Wild celery or water celery** *(Vallisneria americana)* green, ribbon-like leaves below the water surface. The flower is small, whitish yellow, visible in the late summer and supported by a coiled stalk so that it floats on the surface. Wild celery often grows in beds near pondweeds, preferring a semi-hard bottom such as sand covered with a thin layer of muck. This plant produces rhizomes.

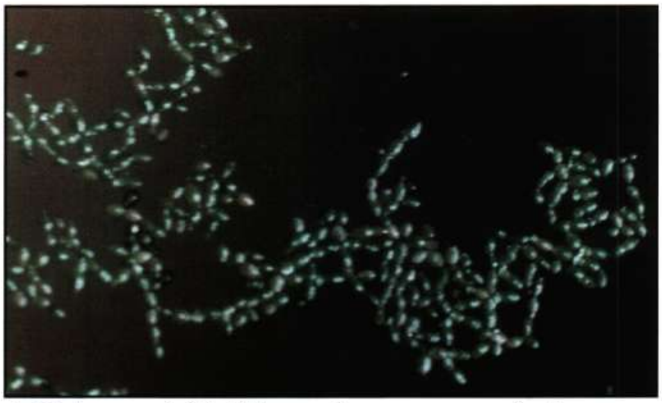
Coontail ▶ *(Ceratophyllum demersum)* is usually rootless but the lower end of the stem is anchored in the sediment early in the season. Later, it floats near the surface. The central stem is hollow and branched. Dark green leaves are arranged in whorls of five to 12 and are usually thicker at the stem tip, giving rise to the raccoon-tail appearance. The spacing between the whorls is variable — plants may be bushy or extremely long and sparse-looking. Coontail grows in clear, usually hard water, adapting to various water levels and turbidity. Coontail is often mistaken for water milfoil, but it can be distinguished from milfoil because the leaves are forked instead of feather-like.



▲ **Elodea** *(Elodea canadensis)* grows entirely below the water surface. It grows best rooted in soft sediment and cool water. It is usually a deep grass-green color and may grow to 6 feet long. The stem is branched and leaves are arranged in whorls of three or four.

FREE-FLOATING PLANTS

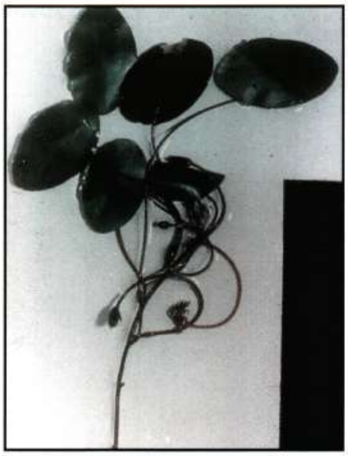
▲ **Duckweeds** *(Lemna minor)* are free-floating, small, green plants. Some types are smaller than a pinhead; others, up to 1/2 inch long. Small roots may or may not grow from the underside of the plant. Leaves and stem are sometimes indistinguishable.



▲ **Watermeal** *(Wolffia spp.)* appears as minute, green grains floating on the water. It is the smallest of all flowering plants. Watermeal has no roots, and plants are often mistaken for seeds.

ROOTED FLOATING PLANTS

▲ **Waterlily** *(Nymphaea* spp.*)* plants have large, orbicular floating leaves. Each has a slit from the edge to the center. The stem is attached to the center of the leaf; the veins radiate from the center and branch or subdivide at the leaf's edge. The waterlily may produce pink, white or yellow flowers with multiple rows of petals that float on the water.



◀ **Watershields** *(Brasenia schreberi)* have 2- to 5-inch-long, oval to elliptic leaves that float on the water surface. The leaves are green on top and reddish underneath. The underside is usually coated with a thick layer of jelly-like material. The stem is attached firmly to the middle of the leaf, and the plant is firmly rooted in the substrate. Watershield may bloom from June through August with a dull reddish purple flower.

ROOTED FLOATING PLANTS

Continued

▲ **American lotus** *(Nelumbo lutea)*. Lotus plants grow large, cup-shaped leaves that extend above the water. The stem is attached at the center of the leaf. The leaf veins radiate from the junction of the stem in all directions and divide near the leaf's edge. Lotus has an extensive underground rootstock and will grow in fairly deep water. The flower is large and pale yellow. A large, flat-topped seed pod follows the flower.

EMERGENT PLANTS

▲ **Cattail** *(Typha* spp.*)*. Cattail leaves are long, flat, about 1 inch wide and grass-like. A long stalk may be produced later in the season bearing a green seed spike at the end that matures to brown. As the seeds start to disperse, the spike comes apart. Inside it is fluffy and white.

▲ **Purple loosestrife** *(Lythrum salicaria)* is an erect perennial weed that is easily identified by the pinkish purple flower spike it bears from July through August. Its leaves are opposite on the stem and lanceolate with a cordate base. The stiff stems may be 2 to 7 feet tall and are four-sided.

CHAPTER 9

CALIBRATION – APPLYING THE RIGHT AMOUNT OF HERBICIDE

Introduction

Aquatic pesticide application boats should be operated by an application team of at least two persons. The two-person team can safely share responsibilities for monitoring application rates. One person may drive the boat, monitor and set boat speed, and monitor the dispersement or application rate of the given pesticide. The other person is usually responsible for filling the spray tank or granular pesticide spreader hopper, directing the spray wand or handgun, and ensuring that the spray or spreading equipment is operating properly. The spray equipment or spreaders used to apply aquatic pesticides should be calibrated so they deliver the proper amount of pesticide to a specific area over a given amount of time. A fairly complete calibration method for aquatic herbicides is included below, although many of the principles and safety precautions are also appropriate for other types of pesticide applications, such as when applying piscicides.

Aquatic pesticides are applied by broadcasting pellets or granules over the water surface, spraying a solution over the water surface with a handgun, and injecting solutions below the water surface with submerged hoses. The applicator must know how much pesticide needs to be applied to a specific area to achieve control of a particular pest or group of pests such as weeds.

Numerous factors must be considered to apply aquatic pesticides accurately. These include boat speed; the total area to be treated; the width of the area to which the pesticide can be applied with a handgun, spreader or trailing hoses as the boat moves forward; pump speed; and the rate at which water is drawn from the lake or pond to dilute and propel the pesticide application.

Many variables complicate the matter. First, it is extremely difficult for the aquatic pesticide applicator to achieve a constant boat speed because of winds, vegetation density and water flows. Pump pressure can also vary during the application if vegetation is sucked into the water supply lines. For this reason, it is necessary for the spray team to work together closely to adjust boat and pump speed to ensure even application rates. A translucent pesticide tank and a detailed area grid map are essential to permit rapid visual confirmation that a specified amount of pesticide is being placed in an area of known dimensions. Hand signals help to facilitate good communication between team members. The application team is the most important component of proper aquatic pesticide application.

As Paraclesus stated in the 16th century, "Only the dose makes the poison." This is particularly true when you're applying aquatic herbicides. All pesticides must be applied at a rate that does not exceed the recommendations that appear on the federal label. Inaccurate application rates may result in sublethal doses — when too little herbicide is applied to a target plant pest. Or "burn off" can occur — when an excessive dose of systemic herbicide is applied and the plant parts contacted by the herbicide die before the herbicide is translocated to the roots of the plant.

Proper selection of application rates is required to:

1) Achieve adequate control of the target weed or pest.
2) Avoid damage to nontarget plants and animals.
3) Avoid waste of pesticides.
4) Satisfy regulatory requirements.

Aquatic herbicide application rates can be figured three ways. The most common method is based on pounds or gallons of herbicide required per acre, usually expressed as surface acre, for control of a given target species. Secondly, aquatic herbicide labels may base application rates on a desired concentration of active ingredient, usually expressed as parts per million (ppm). Some herbicides used for emergent plant control are to be applied as a percent active ingredient in a solution applied to the target pest.

No matter which rate the label requires, knowing the amount of product needed for a particular water body requires knowing the size of the treatment area. always determine the treatment area size before purchasing pesticides. Knowing the treatment area size will help you avoid buying too much or too little pesticide product.

Applications Based on Area

When determining the amount of herbicide to be applied for a given surface area or for a specific concentration in the water, the first thing you need to do is measure the area to be treated. Small ponds can be measured with a tape measure, by stepping off, if you know your step length, or with a rangefinder. When using a rangefinder, check frequently to make sure it is accurate within the distances being measured. On water, distances can be measured by dragging a floating rope of known length behind a boat and dropping buoys every time the end of the rope passes a buoy (so that the distance equivalent to the length of the rope can be measured again), by using a rangefinder, or by using a map and some type of planimeter, if a map with an adequate legend is available. Once accurate distances have been measured and marked, boat speed (in feet per second or other convenient measure) at a specific rpm can be determined by timing the boat through any marked distance. Distances can then be estimated by operating the boat for the length of time equivalent to a desired distance. Boat speed should be measured in two directions and averaged to allow for differences caused by wind or current.

The acreage of small rectangular ponds and lakes is easily calculated by multiplying their length times their width, measured in feet, and dividing by the number of square feet in 1 acre, which is 43,560, as follows (Example 1):

$$\text{SURFACE ACRES} = \frac{\text{length (ft)} \times \text{width (ft)}}{\text{43,560 (sq ft per acre)}}$$

Example 1. What is the acreage of a rectangular pond that measures 800 ft by 440 ft?

$$\text{SURFACE ACRES} = \frac{\text{length (ft)} \times \text{width (ft)}}{\text{43,560 (sq ft per acre)}}$$

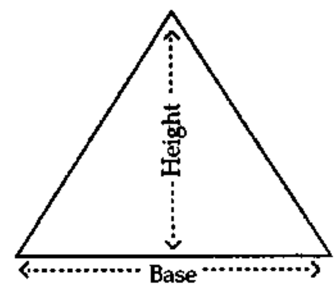
$$\text{SURFACE ACRES} = \frac{\text{800 ft} \times \text{440 ft}}{\text{43,560 sq ft}}$$

$$= \frac{\text{352,000 sq. ft.}}{\text{43,560 sq. ft.}}$$

SURFACE ACRES = 8.1

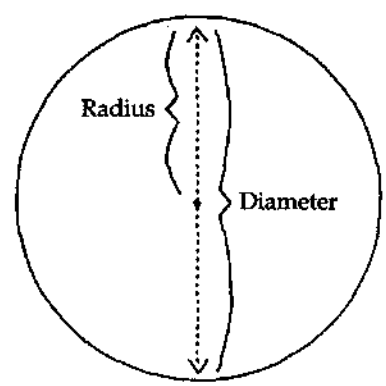
Many lakes and small coves are not rectangular but may be more or less triangular or circular. The equations for determining the area of a triangle or circle are as follows (Example 2).

$$\text{AREA OF A TRIANGLE (ACRES)} = \frac{\text{1/2 base (ft)} \times \text{height (ft)}}{\text{43,560 sq ft per acre}}$$

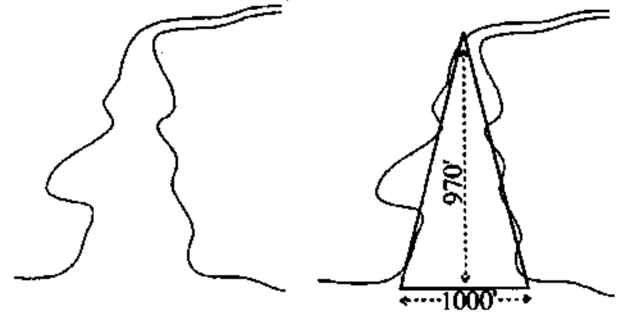


$$\text{AREA OF A CIRCLE (ACRES)} = \frac{3.14 \times \text{radius}^2 \text{ (ft)}}{\text{43,560 sq ft per acre}}$$

Radius = 1/2 diameter



Example 2. Estimate the area, in acres, of the following cove.

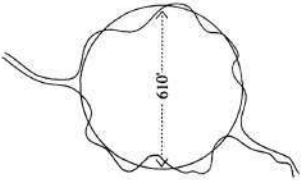


$$\textbf{AREA OF TRIANGLE (ACRES)} = \frac{1/2 \text{ base (ft)} \times \text{height (ft)}}{43{,}560}$$

$$\textbf{AREA OF TRIANGLE (ACRES)} = \frac{1/2(1000) \times 970}{43{,}560}$$

AREA OF TRIANGLE (ACRES) = 11.1

Example 3. Estimate surface area, in acres, of the following water body.



DIAMETER = 610 ft

RADIUS = 1/2 x diameter

RADIUS = 1/2 x (610)

RADIUS = 305 ft

$$\textbf{AREA OF CIRCLE (ACRES)} = \frac{3.14 \times \text{radius}^2}{43{,}560}$$

$$\textbf{AREA OF CIRCLE (ACRES)} = \frac{3.14 \times (305)^2}{43{,}560 \text{ sq. ft.}}$$

$$= \frac{292{,}098.5 \text{ sq. ft.}}{43{,}560 \text{ sq. ft.}}$$

AREA OF CIRCLE (ACRES) = 6.7

The shapes of many lakes and coves are very irregular and do not conform to any geometric figure. In this case, the area can be estimated as follows:

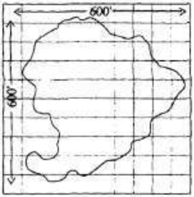
1) Inscribe a sketch of the lake inside a rectangle.

2) Measure the area of the rectangle.

3) Estimate the proportion of the rectangle that is occupied by the lake (this step can be facilitated by using graph paper and dividing the number of blocks occupied by the lake by the total number of blocks in the rectangle).

4) Multiply the fraction of the rectangle occupied by the lake times the area of the rectangle for the lake's acreage (Example 4).

Example 4. Estimate the surface area, in acres, of the following irregularly shaped lake.



Step 1

$$\textbf{AREA OF RECTANGLE (ACRES)} = \frac{\text{Length (ft)} \times \text{Width (ft)}}{43{,}560}$$

$$\textbf{AREA OF RECTANGLE. (ACRES)} = \frac{600 \text{ ft.} \times 600 \text{ ft}}{43{,}560 \text{ sq. ft.}}$$

$$= \frac{360{,}000 \text{ sq. ft.}}{43{,}560 \text{ sq. ft.}}$$

AREA OF RECTANGLE (ACRES) = 8.26

Step 2

The number of squares in the rectangle is 100 and the number of squares in the lake is 51. Therefore the fraction of the rectangle occupied by the lake is 51/100.

Step 3

$$\textbf{AREA OF LAKE} = \frac{\text{area of rectangle} \times \text{number of squares in lake}}{\text{number of squares in rectangle}}$$

$$\textbf{AREA OF LAKE} = \frac{8.26 \text{ acres} \times 51}{100}$$

AREA OF LAKE = 4.2 acres

Measurement of areas for large herbicide applications is best done in rectangular shapes, and plots should be marked as subplots of smaller areas. For example, a 200-acre area should be marked in subplots of 25 acres or smaller so that the application rate can be continually checked (Example 5).

It may be helpful to lay plots out to conform to swath width so that a certain number of swaths will be equivalent to an acre (43,560 square feet)(Example 6). Dividing swath width into 43,560 tells how long a one-acre swath would be. Using this as one dimension of the plot, you can calculate the other dimension by dividing the length of a one-acre swath into the area of the entire plot. In this way, you can keep very close track of your application because you know that, with every swath, you should apply the rate prescribed per acre.

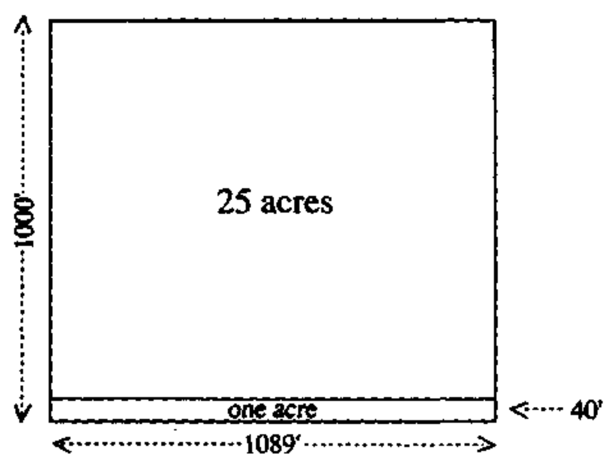
Depending on the size of the plot, you can make a dimension a half swath, two swaths, etc. Also, you can assume that the herbicide diffuses between swaths and define the "effective swath" as the distance between the centers of two adjacent treated swaths (Example 6).

Example 5. A pellet herbicide formulation is to be applied to a 25 acre plot in a large lake with a spreader that has a swath width of 40 feet. Show the rectangular plot layout that could be used so that each pass would treat one acre.

$$\text{LENGTH OF ACRE SWATH} = \frac{\text{sq ft per acre}}{\text{swath (ft)}}$$

$$\text{LENGTH OF ACRE SWATH} = \frac{43{,}560 \text{ sq ft}}{40 \text{ ft}}$$

LENGTH OF ACRE SWATH = 1,089 ft



Therefore, the length of one side of the plot can be 1089 feet. Now determine the length of the other side of the plot as follows:

AREA OF PLOT (SQ FT) = area of plot (acres) x sq ft per acre

AREA OF PLOT (SQ FT) = 25 x 43,560

AREA OF PLOT (SQ FT) = 1,089,000

$$\text{WIDTH (FT)} = \frac{\text{area of plot (sq ft)}}{\text{length (ft)}}$$

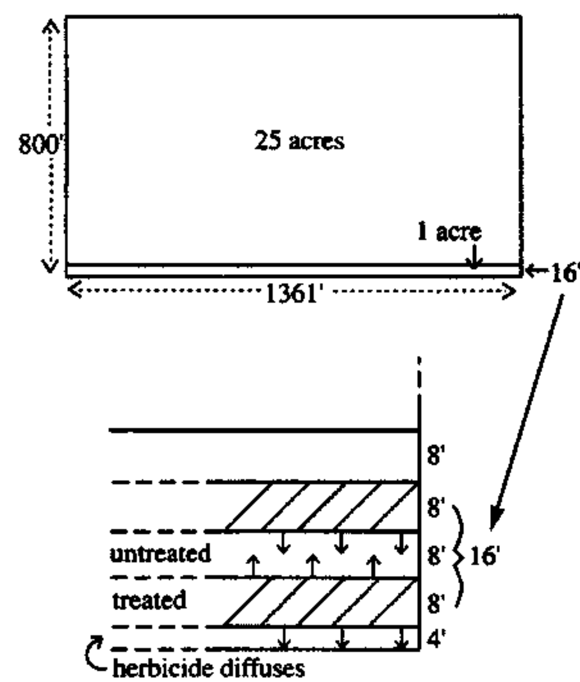
$$\text{WIDTH (FT)} = \frac{1{,}089{,}000}{1089}$$

WIDTH (FT) = 1,000

Note that the number of 1-acre swaths (25) could have been multiplied times the swath width of 40 ft to arrive at the 1000-ft width. This can also be used to check your calculations.

Example 6. Swath width for boom applications to submersed aquatic weeds can be considered the boom length or an approximation. Often only alternate swaths are actually treated, so the effective swath width becomes twice the boom length. It is assumed that the herbicide, with the help of turbulence caused by the spray boat and environmental factors, will mix throughout the water column.

Show the rectangular plot layout that could be used if 25 acres are to be treated with a liquid herbicide, using an 8-foot boom treating alternate swaths, so that each pass would treat one-half acre.



If every other 8 feet is actually covered, then the effective swath width is 16 ft.

$$\text{LENGTH OF ACRE SWATH (FT)} = \frac{\text{sq ft per acre}}{\text{length of effective swath (ft)}}$$

$$\text{LENGTH OF 1/2 ACRE SWATH (FT)} = \frac{1/2 \text{ (sq ft per acre)}}{\text{length of effective swath (ft)}}$$

$$\text{LENGTH OF 1/2 ACRE SWATH (FT)} = \frac{1/2(43{,}560)}{16}$$

LENGTH OF 1/2 ACRE SWATH (FT) = 1,361

The length of the plot can be 1,361 feet. Now determine the width of the plot as follows:

AREA OF PLOT (SQ FT) = area of plot (acres) x sq ft per acre

AREA OF PLOT (SQ FT) = 25 x 43,560

AREA OF PLOT (SQ FT) = 1,089,000

$$\text{WIDTH OF PLOT (FT)} = \frac{\text{area of plot (sq ft)}}{\text{length of plot (ft)}}$$

$$\text{WIDTH OF PLOT (FT)} = \frac{1{,}089{,}000}{1{,}361}$$

WIDTH OF PLOT (FT) = 800

To determine the amount of herbicide needed for an application, multiply the recommended rate per acre times the surface area.

Example 7. How much herbicide is needed to treat an 8.1-acre lake at the rate of 120 pounds of granular herbicide per acre?

HERBICIDE NEEDED = pounds per acre x acres

HERBICIDE NEEDED = 120 pounds per acre x 8.1 acres

HERBICIDE NEEDED = 972 pounds

Applications Based on Herbicide Concentrations

Herbicide labels usually have tables from which the applicator can determine the appropriate amount of herbicide formulation for a desired concentration and given water depth. If a table is not provided, or if you need to calculate the (potential) concentration of herbicide in water for a given depth when the recommendation is given only as a surface acre application, you will need to calculate the amount of herbicide to use (Example 9).

Herbicide concentration in water is usually referred to in **parts per million (ppm)** on a weight:weight basis. Before determining concentration or amount of herbicide to use for a given concentration, you must first measure the surface area, as described earlier, and water depth so that you can calculate water volume. If water depth is not uniform, it is important to determine average depth. In small ponds, depth should be measured across the pond in at least two directions, taking sufficient measurements to describe the pond's depth adequately. The number of directions needed will depend on the shape and the bottom uniformity of the pond and will have to be determined on site. Average depth is calculated as follows:

$$\text{AVERAGE DEPTH} = \frac{\text{sum of all measurements}}{\text{number of measurements}}$$

A convenient unit for measuring water volume for determining herbicide concentration is the acre-foot, which is determined by multiplying the average depth times the surface area in acres as follows:

ACRE-FEET = average depth (feet) x surface area (acres)

The amount of herbicide needed for a desired concentration can now be calculated by using the following equation:

HERBICIDE NEEDED (POUNDS A.I.) = ppm x acre-feet x 2.7

The number 2.7 is a constant because 1 acre-foot of water weighs 2,700,000 pounds. In other words, every 2.7 pounds of a substance in 1 acre-foot of water is equivalent to 1 ppm.

The concentration of a pesticide in water can be calculated for a given application rate by re-arranging the last equation so that:

$$\text{PPM} = \frac{\text{pesticide (pounds a.i.)}}{\text{acre-feet x 2.7}}$$

One more calculation must be made. Because the amount of pesticide needed has been calculated for the active ingredient, the amount of formulation needed must be determined. For dry formulations (wettable powders, dry flowables, pellets and granules), the amount of active ingredient is divided by the percent active ingredient expressed as a decimal; i.e., if the formulation is an 80 WP, divide by 0.80. For liquid formulations, divide by the amount of herbicide per gallon to determine gallons of formulation to apply (e.g., for a 4-pound-per-gallon EC, divide by 4).

Example 8. A farm pond is found to be 1.6 acres in surface area, and the following depths are measured: direction one — 2, 3, 4, 4, 4, 6, 6, 4, 2 feet; direction two — 2, 4, 6, 6, 6, 6, 6, 4, 2 feet. How much copper sulfate is needed for a copper (as elemental) concentration of 0.5 ppm for algae control? (Hint: copper sulfate is sold as cupric sulfate pentahydrate, which is 25% elemental copper.)

$$\text{AVERAGE DEPTH} = \frac{\text{sum of measurements (ft)}}{\text{number of measurements}}$$

$$\text{AVERAGE DEPTH} = \frac{(2+3+4+4+4+6+6+4+2) + (2+4+6+6+6+6+6+4+2)\text{ (ft)}}{18}$$

AVERAGE DEPTH = 4.3 ft

ACRE-FEET = average depth x surface area (acres)

ACRE-FEET = 4.3 feet x 1.6 acres

ACRE-FEET = 6.88

HERBICIDE A.I. = ppm x acre-feet x 2.7

HERBICIDE A.I. = 0.50 x 6.88 x 2.7

HERBICIDE A.I. = 9.29 pounds elemental copper

Copper sulfate is 25% elemental copper. Therefore:

$$\text{Pounds copper sulfate} = \frac{9.29}{.25} = 37.15$$, or roughly 37 pounds of copper sulfate.

Example 9 (optional). A granular herbicide (20% active ingredient) is applied at a rate of 150 pounds per acre to 5 acres of water 6 feet deep in a large lake to control spatterdock. A homeowner asks if this herbicide application will be toxic to fish. Although you are confident that there is no potential problem — there was caution on the label and you have experience with such applicatins— you can give the homeowner concrete facts to support your answer.

A call to the county MSU Extension office reveals that the experimental toxic concentration of this herbicide formulation is about 3.3 ppm to fathead minnows (a sensitive test organism).

The maximum potential concentration of herbicide in the water must be calculated so that it can be compared with the toxic level. First, calculate the amount of herbicide active ingredient applied by multiplying 150 pounds, the amount of formulation applied per acre, by 0.20, the percent active ingredient expressed as a decimal. Therefore, 30 pounds (150 pounds x 0.20 = 30 pounds) of herbicide active ingredient were applied per acre.

Before calculating the concentration of herbicide, calculate acre-feet as follows:

ACRE-FEET = average depth x surface area (acres)

ACRE-FEET = 6 x 5

ACRE-FEET = 30

The concentration of herbicide can now be calculated as follows:

$$\text{PPM} = \frac{\text{herbicide (pounds a.i.)}}{\text{acre-feet} \times 2.7}$$

$$\text{PPM} = \frac{30}{30 \times 2.7}$$

PPM = 0.37

After comparing the toxic concentration of 3.3 ppm to the maximum potential concentration of 0.37 ppm, you can tell the homeowner that even if the maximum concentration did occur, there would be almost a tenfold safety factor. You could further explain to the homeowner that this concentration would probably not occur because the herbicide is quickly taken up by aquatic plants, diluted in the surrounding water and adsorbed to bottom sediments, where it degrades over time.

Applications by Parts or Percent of Herbicide in Spray Solution

Some herbicide labels recommend a proportion of herbicide to final spray tank mix. For example, a label may recommend using 1 gallon of herbicide formulation to 20 gallons of spray mix. Calculate the amount of herbicide to use for spray tank volumes other than that given on the label as follows:

$$\text{HERBICIDE PER TANK} = \frac{\text{volume of spray tank} \times \text{herbicide amount given}}{\text{spray mix amount given}}$$

This equation can be used for any unit as long as the same units are used on both sides of the equation.

Example 10. A herbicide label recommends mixing 1 gallon of herbicide formulation to 20 gallons final spray mix and spraying vegetation to wet. How much herbicide would be used with 500 gallons of spray mix?

$$\text{HERBICIDE PER TANK} = \frac{\text{volume of spray tank} \times \text{herbicide amount given}}{\text{spray mix amount given}}$$

$$\text{HERBICIDE PER TANK} = \frac{500 \text{ X } 1}{20}$$

HERBICIDE PER TANK = 25 gallons (since all units used are in gallons)

Spray tank concentrations are often recommended as a specified percent solution (volume:volume). Percent actually means parts per 100. Therefore, for each 100 parts (volume) of spray tank mix, one part (volume) of herbicide would be added for each 1 percent recommended. The amount of herbicide to be added to a spray tank for a recommended percent (volume:volume) solution is calculated as follows:

$$\text{HERBICIDE PER TANK} = \frac{\text{spray tank volume x \% solution required}}{100}$$

The solution to this equation will be in whatever units the spray tank volume is in. Note: The concentration of herbicide active ingredient in the tank will depend on the amount of active ingredient per gallon of formulation. Therefore, percent solutions of different formulations of the same herbicide may not be the same.

Example 11. Four gallons of 1.5 percent spray mix are to be prepared for application to emergent vegetation on a pond bank using a backpack sprayer. How much herbicide should be mixed in the spray tank before bringing up to the final volume?

$$\text{HERBICIDE PER TANK} = \frac{\text{spray tank volume x \% solution required}}{100}$$

$$\text{HERBICIDE PER TANK} = \frac{\text{4 gal x 1.5}}{100}$$

HERBICIDE PER TANK = .06 gal

Because containers graduated in hundredths of a gallon are rare, to say the least, the answer can be converted to fluid ounces by multiplying by 128 (the number of fluid ounces in 1 gallon) as follows:

FLUID OUNCES = gal x 128 (fluid ounces per gal)

FLUID OUNCES = .06 X 128

FLUID OUNCES = 7.68

Alternatively, liquid ounces could have been used initially in the equation to obtain the same answer as follows:

$$\text{HERBICIDE PER TANK} = \frac{\text{spray tank volume x \%solution desired}}{100}$$

$$\text{HERBICIDE PER TANK} = \frac{\text{(4 gal x 128 ounces per gal) ounces x 1.5}}{100}$$

HERBICIDE PER TANK = 7.68 fluid ounces

Equipment Calibration

Once you have determined the size of the area to be treated and the desired concentration of pesticide, you must adjust your equipment's output to ensure that the label rate of pesticide is being applied. The process of equipment adjustment to obtain a desired application rate is known as **calibration.**

Maintaining an accurate application rate is difficult when applying aquatic herbicides because the equipment is mounted in a boat. Environmental factors such as wind velocity and speed, water flow and vegetation density make it difficult to maintain a constant speed and perfect course. Although the initial calibration of equipment for application of aquatic herbicides should be precise, the applicator's constant attention is necessary to make the application rate as constant as possible. When applying herbicides to water, the herbicides will mix within the treatment area so that precision becomes a little less important. Still, without any question, proper calibration and constant attention by the applicator are the most important components of any application.

The following materials will be needed to calibrate aquatic herbicide application equipment:

(1) Watch (a stopwatch that is marked in tenths of a minute is useful).

(2) Calculator (unless you are good at doing math in your head).

(3) Tape measure – or known length of your steps.

(4) 100-ft floating rope with a float tied to the end.

(5) Buoys or poles.

(6) Scale that will weigh up to 20 pounds.

(7) Blank herbicide granules. Enough 5-gallon buckets to measure water from each nozzle of your spray boom; one of these should be marked or graduated in pints or quarts.

(9) Quart container calibrated in ounces (only if calibrating suction/induction system).

You can calibrate equipment in various ways. Any is acceptable as long as the correct end is achieved. In any of the methods, you must determine the gallons per acre **(GPA)** of spray solution for tank-mix equipment, the actual **GPA** of herbicide for suction systems, or pounds per acre **(PPA)** of granular or pellet herbicide formulations.

The equations for determining **GPA** and **PPA** are:

$$\text{GPA} = \frac{\text{gallons per minute (GPM) from spray system}}{\text{acres per minute}}$$

and

$$\text{PPA} = \frac{\text{pounds per minute from spreader}}{\text{acres per minute}}$$

GPM or **POUNDS PER MINUTE** are measured directly from the equipment.

There are several ways to determine GPM for boom-applied tank mix equipment:

(1) Run the pump until all air is out of the lines. Place a bucket under each nozzle of the boom. Run the pump for one minute while catching the discharge. Measure the water in each bucket and add these quantities together, or pour them into one bucket and measure this quantity to get the **GPM.**

If you measure the amount from each nozzle, you can determine nozzle uniformity as follows: add the quantities from each nozzle together and divide by the number of nozzles to determine the average nozzle output. Then determine the percent deviation of each nozzle by dividing the actual nozzle output into the difference between the average and actual output and multiplying by 100. If a nozzle deviates by 10 to 15 percent (an acceptable range of deviation depends on the accuracy needed for particular type of application), check it for clogging or size (wrong size or wear). (Alternatively, a quick check for nozzle uniformity can be made visually.) The equation for nozzle uniformity is:

$$\%\text{DEVIATION} = \frac{\text{average nozzle output} - \text{individual nozzle output}}{\text{average nozzle output}} \times 100$$

(2) If nozzle uniformity is not a concern, and hoses are long enough, all hoses can be placed into one bucket and the output measured and the pump run for 1 minute. Using this method, if the pump output is greater than 5 GPM, it will be necessary to run the test for less time. For example, run the pump for 30 seconds and multiply the output by 2 for the GPM.

(3) If nozzle uniformity is not a concern, the tank refill method can be used as an alternative. Put some water in the tank and run it until all air is out of the lines. Fill the tank completely and run the pump for 1 minute. Measure the amount of water that is necessary to refill the tank to determine GPM. For greater accuracy, the pump can be run for a longer period of time and the amount required to fill the tank divided by the number of minutes that the pump was run to obtain GPM.

GPM for handgun applications can be determined either by using the tank refill method or by catching the output from the handgun in a bucket for 1 minute (or some other known period of time).

GPM for direct metering equipment is determined by measuring the amount of liquid that is drawn out of a container graduated in ounces in a minute or greater period of time. Ounces are converted to gallons by dividing by 128 (because there are 128 ounces in a gallon).

Pounds per minute can be measured by two methods:

(1) Fill the hopper on the spreader with blank herbicide and catch the output with a box or bag that is constructed to fit underneath. When calibrating for rates exceeding 100 PPA, 1 minute is sufficient. For lower rates, 2 or 3 minutes will be necessary for accurate weighing.

(2) If a container is not available to catch the output (be careful with plastic bags because they tend to get caught and tangle in the spreader's paddle), weigh a known quantity — 10 pounds is good — of blank herbicide and measure the time in seconds that it takes for all of the material to go out. To obtain pounds per minute, divide the pounds that were put in the hopper by the seconds that it took to run out and multiply by 60 (number of seconds in a minute).

Now **ACRES PER MINUTE** must be determined. The following equation can be used to determine **ACRES PER MINUTE:**

$$\text{ACRES PER MINUTE} = \frac{\text{swath width (ft)} \times \text{speed (mph)} \times 88}{43{,}560 \text{ (sq.ft/acre)}}$$

For ease of calculation, this equation can be simplified by dividing both the top and the bottom of the equation by 88 (the number of feet traveled per minute at 1 mph; this converts mph to miles per minute). The new equation is:

$$\text{ACRES PER MINUTE} = \frac{\text{swath width (ft)} \times \text{speed (mph)}}{495}$$

$\{43{,}560 \div 88 = 495\}$

Because it is easy to multiply by 2 and divide by 1,000 (simply move the decimal point three places to the left), this equation can be simplified further by multiplying both the top and the bottom of the equation by 2 and rounding 990 in the bottom to 1,000, with the introduction of only 1 percent error, to:

$$\text{ACRES PER MINUTE} = \frac{2 \times \text{swath width (ft)} \times \text{speed (mph)}}{1000}$$

Swath width is measured directly from the equipment to be used. For agricultural boom applications, swath width is defined as nozzle spacing times the number of nozzles. Swath width for boom applications to submersed aquatic weeds can be considered the boom length or an approximation. Often, only every other strip is treated in the treatment area and the swath width becomes twice the boom length. It is assumed that the herbicide, with the help of turbulence caused by the spray boat and environmental factors, will mix throughout the water column. Swath width for a handgun is measured by actually spraying water as the boat comes in toward shore and having someone on shore mark the distance covered. Swath width of a granular spreader is measured in a similar fashion.

Another measurement must be made: **SPEED.**

To determine boat speed, measure a distance at least 100 feet long in the lake, using the 100-foot floating rope, and mark the distance with the buoys or poles. Operate the boat, with the spray tank half full and the number of persons and other gear that the boat will carry at a comfortable speed (usually a fast idle or equivalent to a fast walking pace), and approach the front marker. As you pass the first marker start timing. As you pass the end marker, note the time in seconds that it required to cover the distance. Do this in the opposite direction and average the two numbers to compensate for going with and against the wind. Determine MPH by the following equation:

$$\textbf{MPH} = \frac{\text{distance traveled (ft)} \times 3600 \text{ (sec)}}{5{,}280 \times \text{time to cover distance (sec)}}$$

This equation can be simplified to:

$$\textbf{MPH} = \frac{\text{distance traveled (ft)}}{\text{time to cover distance (sec)} \times 1.47}$$

If you have a stopwatch that reads in tenths of a minute, you can measure your time in minutes and use the equation:

$$\textbf{MPH} = \frac{\text{distance traveled (ft)}}{\text{time to cover distance (min)} \times 88}$$

The drawback of using the previous equations for determining **ACRES PER MINUTE** is that speed must be calculated in mph. An alternative "one-shot" equation is:

$$\textbf{ACRES PER MINUTE} = \frac{\text{swath width (ft)} \times \text{distance traveled (ft)} \times 60}{43{,}560 \times \text{time to cover distance (sec)}}$$

If a stopwatch that measures in tenths of a minute is used, 60 in the top part of the equation (numerator) can be eliminated if the time to cover the distance is expressed in minutes, rather than seconds.

Varying Rate of Application

Rate of application can be regulated by varying equipment output, **GPM** or **POUNDS PER MINUTE**, or by changing the rate at which the equipment covers area, **ACRES PER MINUTE.**

GPM can be varied by changing pressure or changing the size or number of nozzles. Changing the size or number of nozzles is used for large changes and changing the pressure regulator for small changes (output will double only when pressure is increased four times).

Herbicide withdrawn by direct metering systems can be varied only by changing the metering orifice in the suction line. There is a small difference in the output of consecutive sizes, so accurate calibration is possible. Changes in output of centrifugal granular spreaders are made by changing settings on the spreader.

Swath width and speed determine the rate of coverage. Changes in swath width or speed will inversely change the rate of coverage. For example, if swath width or speed is doubled, the rate of coverage or **ACRES PER MINUTE** will be cut in half. When spraying with a handgun, the swath can be varied considerably. Although actual boom length is fixed, the effective swath width of a boom for submersed weed control applications can be changed by applying in bands. Forward speed can be varied within a relatively narrow range. Normally the speed is 3 to 4 mph when treating by boat at idle speed. Greater or lesser boat speeds can be used under certain circumstances.

Examples

All of the equations, along with some alternatives, that are needed to calibrate equipment have now been explained. The following examples should help further clarify the process of equipment calibration.

Example 12. Assume that a 100-gallon tank mix sprayer mounted in a johnboat is being calibrated. The sprayer has an 8-foot boom with four drop hoses. A herbicide is to be applied at the rate of 2 gallons per acre for weed control.

A 200-foot distance is marked off. It is found that the boat travelled the 200 feet in one direction in 54 seconds and the opposite direction in 56 seconds. The numbers are averaged:

$$\frac{54 + 56}{2} = 55$$

MPH is calculated as follows:

$$\textbf{MPH} = \frac{\text{distance traveled (ft)}}{5{,}280} \times \frac{3600}{\text{time to cover distance (sec)}}$$

$$\textbf{MPH} = \frac{200}{5{,}280} \times \frac{3600}{54}$$

MPH = 2.5

Calculate acres per minute as follows:

$$\text{Acres per minute} = \frac{\text{swath width (ft) x speed (mph)}}{495}$$

$$\text{Acres per minute} = \frac{8 \times 2.5}{495}$$

Acres per minute = 0.04

Output was measured from each drop hose for 1 minute to determine **GPM**, and the following values were obtained:

hose 1 – 60 fluid ounces
hose 2 – 100 fluid ounces
hose 3 – 110 fluid ounces
hose 4 – 105 fluid ounces

Obviously there was a problem with hose #1 because its output was substantially lower than the others. Deviations from the average output are calculated as follows:

$$\textbf{AVERAGE OUTPUT} = \frac{60+100+110+105 = 93.75}{4}$$

(93.75 can be rounded off to 94 for ease of calculation)

$$\textbf{\%DEVIATION} = \frac{\text{average nozzle output – individual nozzle output x 100}}{\text{average nozzle output}}$$

$$\textbf{\% DEVIATION} \text{ (hose \#1)} = \frac{60\text{-}94}{94} \times 100 = -36\%$$

$$\textbf{\% DEVIATION} \text{ (hose \#2)} = \frac{100\text{-}94}{94} \times 100 = 6\%$$

$$\textbf{\% DEVIATION} \text{ (hose \#3)} = \frac{110\text{-}94}{94} \times 100 = 17\%$$

$$\textbf{\%DEVIATION} \text{ (hose \#4)} = \frac{105\text{-}94}{94} \times 100 = 12\%$$

Because one nozzle in this example was very low, it made the average very low and several deviations are high. Hoses 2, 3 and 4 are consistent with each other, however, so they are probably ok. Removal of the nozzle from hose #1 reveals that it is clogged with pieces of a disk that was replaced in the pressure regulator last week. Because foreign matter has been found in the system, all nozzles are removed and the system is flushed to avoid another problem. Remeasuring output for one minute yielded the following values:

hose #1 – 115 fluid ounces
hose #2 – 120 fluid ounces
hose #3 – 110 fluid ounces
hose #4 – 118 fluid ounces

Check these to see if they fall within 15 percent of the average output.

GPM can now be calculated by adding up the output from all four nozzles as follows:

GPM = 115+120+110+118

GPM = 463 fluid ounces

Convert fluid ounces to gallons by dividing by 128, the number of fluid ounces per gallon, as follows:

$$\frac{\text{463 fluid ounces per min}}{\text{128 fluid ounces per gal}} = 3.6 \textbf{ GPM}$$

Now calculate **GPA** as follows:

$$\textbf{GPA} = \frac{\text{GPM}}{\text{Acres per minute}}$$

$$\textbf{GPA} = \frac{3.6}{0.04}$$

GPA = 90

Two gallons of herbicide are to be applied per acre, and the spray volume is 90 **GPA**, so 2 gallons of herbicide plus adjuvants will be mixed with enough water to make a final volume of 90 gallons, and this will treat 1 acre. But **REMEMBER** that this is an approximation because environmental conditions can change while applying and the applicator must pay constant attention to his output and the area being treated (i.e., when 1/4 acre has been treated 1/4 of the 90 gallon tank should have been applied; if not, the boat must be slowed or speeded up accordingly).

Remember that the herbicide you apply can be in strips and assume diffusion between the strips. In this example, every other 8 feet (swath width) could be treated to give an effective swath width of 16 feet. This will be advantageous because it will cut both spray time and spray volume in half and save additional time in tank mixing. It might be obvious that this change will double **ACRES PER MINUTE** and cut **GPM** in half, but the calculations go as follows:

$$\textbf{ACRES PER MINUTE} = \frac{\text{swath (ft)} \times \text{speed (mph)}}{495}$$

$$\textbf{ACRES PER MINUTE} = \frac{16 \times 2.5}{495}$$

$$\textbf{ACRES PER MINUTE} = 0.08$$

$$\textbf{GPA} = \frac{\text{GPM}}{\text{ACRES PER MINUTE}}$$

$$\textbf{GPA} = \frac{3.60}{0.08}$$

$$\textbf{GPA} = 45$$

Therefore, four gallons of herbicide and sufficient water are placed in the tank for a total volume of 90 gallons that will treat 2 acres.

Example 13. A direct metering system is to be calibrated to apply herbicide by handgun to control an emergent weed. The herbicide label requires an application rate of 2 to 4 quarts of herbicide per acre in a spray volume of 100 to 200 gallons of water. Because the label requires a specified spray volume, two measurements must be made — output from the handgun and rate of herbicide metered into the system.

Because this is a foliar application to the weed, it is desirable to go as slowly as possible to ensure good coverage. With the boat idled down as low as possible, it takes an average of 114 seconds to cover the distance of 200 feet (**MPH** will not be used in this solution, but the student should use the equation previously given to calculate **MPH** for practice — it should work out to 1.2 MPH). Swath width is measured to be 15 feet and output from the handgun is measured to be 6 **GPM**.

Calculate **ACRES PER MINUTE** as follows (using the "one-shot" equation):

$$\textbf{ACRES PER MINUTE} = \frac{\text{swath (ft)} \times \text{distance traveled (ft)} \times 60}{43{,}560 \times \text{time to cover distance (seconds)}}$$

$$\textbf{ACRES PER MINUTE} = \frac{15 \times 200 \times 60}{43{,}560 \times 114}$$

$$\textbf{ACRES PER MINUTE} = .036$$

Now calculate GPA as follows:

$$\textbf{GPA} = \frac{\text{GPM}}{\text{Acres per minute}}$$

$$\textbf{GPA} = \frac{6}{.036}$$

$$\textbf{GPA} = 167$$

The equipment is delivering the desired spray volume of 100 to 200 gallons per acre.

Now measure **GPM** of herbicide being metered so that this can be used to calculate **GPA** of herbicide being applied. Because the rate of herbicide withdrawal is low, the pump is run for 5 minutes while herbicide withdrawal is measured, and it is found that 17 fluid ounces are withdrawn in the 5 minutes. Therefore, 3.4 fluid ounces (17 divided by 5) are withdrawn per minute. This is converted to **GPM** by dividing by 128, the number of fluid ounces in a gallon. Therefore, **GPM** is 0.027. Now calculate **GPA** as follows:

$$\textbf{GPA} = \frac{\text{GPM}}{\text{Acres per minute}}$$

$$\textbf{GPA} = \frac{0.027}{0.036}$$

$$\textbf{GPA} = 0.75$$

Because there are 4 quarts in a gallon, 0.75 gallons is 3 quarts. Three quarts per 167 gallons will be perfect to allow for small amounts of underspray and overspray and still be within the label requirement of 2 to 4 quarts in 100 to 200 gallons of spray mix per acre.

Note: If herbicide withdrawal had been too low, a larger orifice would have to be used. Conversely, if it had been too high, a smaller orifice would have to be installed.

Example 14. In Example 13 herbicide withdrawal was measured and it turned out to be the desired amount. It would be better to calculate beforehand the desired **GPM** (in fluid ounces) that are required for a given boat speed, swath width and application rate. Using the information from Example 13 the fluid ounces that should be withdrawn can be calculated as follows:

Rearrange the equation

$$\textbf{GPA} = \frac{\text{GPM}}{\text{Acres per minute}}$$

to

GPM = Acres per minute x GPA.

Then

GPM = 0.036 x 0.75

GPM = 0.027

or

0.027 GPM x 128 fluid ounces per gallon = 3.5 fluid ounces per minute.

If small (young) weeds were being treated and we wanted to use the low end of the label rate, or 2 quarts (0.50 gallon), it would be calculated as follows:

GPM = Acres per minute x GPA

GPM = 0.036 x 0.50

GPM = 0.018

or

0.018 GPM x 128 fluid ounces per gallon = 2.3 fluid ounces per minute.

Example 15. A centrifugal spreader must be calibrated to apply 40 pounds of herbicide formulation per acre. Swath width was measured to be 40 feet and speed was calculated to be 2.5 mph as in Example 11 (It may be helpful for you to go back and recalculate this now for practice in working a problem completely through.)

Calculate **ACRES PER MINUTE** using the simplified equation as follows:

$$\text{ACRES PER MINUTE} = \frac{2 \times \text{swath (ft)} \times \text{speed (mph)}}{1000}$$

$$\text{ACRES PER MINUTE} = \frac{2 \times 40 \times 2.5}{1000}$$

ACRES PER MINUTE = 0.2

Calculate how many **POUNDS PER MINUTE** are required for the necessary 40 **PPA** at the given 40-foot swath and 2.5 **MPH** (similar to the method that was used in Example 13 for calculating ounces to be withdrawn) as follows:

Rearrange the equation

$$\text{PPA} = \frac{\text{Pounds per minute}}{\text{Acres per minute}}$$

to

POUNDS PER MINUTE = Acres per minute x PPA

then

POUNDS PER MINUTE = 0.20 x 40

POUNDS PER MINUTE = 8

To calibrate the spreader you must find a setting that will deliver 8 **POUNDS PER MINUTE**. However, you find that the lowest setting on this spreader where clogging does not occur delivers pellets at a rate higher than 8 **POUNDS PER MINUTE**. To use a higher rate, you must increase boat speed and ACRES PER MINUTE. So, you operate the boat through the 200-foot course at increased engine RPM, timing it at an average of 34 seconds (down and back).

Calculate **ACRES PER MINUTE** using the one-shot equation (also calculate mph and use alternative equations for practice and to gain confidence) as follows:

$$\text{ACRES PER MINUTE} = \frac{\text{swath (ft)} \times \text{distance (ft)} \times 60}{43{,}560 \times \text{time to cover distance (sec)}}$$

$$\text{ACRES PER MINUTE} = \frac{40 \times 200 \times 60}{43{,}560 \times 34}$$

ACRES PER MINUTE = 0.32

Calculate the **POUNDS PER MINUTE** that will result in an application rate of 40 pounds per acre in a 40-foot swath at the new speed as follows:

POUNDS PER MINUTE = Acres per minute x PPA

POUNDS PER MINUTE = 0.32 X 40

POUNDS PER MINUTE = 12.8

To calibrate the spreader at the new speed, you need to find a spreader setting that will deliver 12 **POUNDS PER MINUTE**. It is helpful to determine spreader output (in **POUNDS PER MINUTE**) through a range of settings on the spreader to refer to for future applications at various rates and speeds. The following outputs are determined for the spreader in this example:

Spreader setting	Pounds per minute
1	clogs
2	clogs
3	10
4	15
5	20

It is not necessary to move the spreader setting small increments because variables such as boat speed, which will vary during the application, will have a greater effect on **PPA** than small changes that can be effected with the spreader setting. In this example, a spreader setting between 3 and 4 will give the desired 12 **POUNDS PER MINUTE**, which will in turn result in the required application rate of 40 **PPA** at the measured speed.

REMEMBER that calibration is the first approximation of what it will take to deliver the correct application rate. The applicator must pay constant attention to maintaining a constant speed and continually be aware of the area covered and the amount of herbicide applied.

Note: Spreader output will differ at given settings for different-sized particles. Separate calibration tables must be made for pellets and granules of various sizes.

Other Useful Equations

$$\text{ACRES PER TANK} = \frac{\text{tank volume (gal)}}{\text{GPA}}$$

HERBICIDE FORMULATION PER TANK = acres per tank x recommended rate per acre

$$\text{ACRE-FEET} = \frac{\text{length (ft) x width (ft) x average depth (ft)}}{43{,}560\ \text{ft}^2/\text{acre}}$$

VOLUME OF RECTANGULAR TANK (ft^3) = length (ft) x width (ft) x depth (ft)

VOLUME OF RECTANGULAR TANK (gal) = length (ft) x width (ft) x depth (ft) x 7.48 (gal/ft^3)

VOLUME OF CYLINDRICAL TANK (gal) = area of the circular end x length x 7.48 (gal/ft^3)

$$\text{SPEED (mph)} = \frac{\text{feet per minute}}{88}$$

CHAPTER 10

FISH MANAGEMENT

In a given water body, it may become necessary to manage populations of certain fish; bottom-rooting fish, such as carp, which increase turbidity; fish that compete with more desirable game fishes for space and food; and stunted sunfish (including many species in the Centrarchidae family: bluegill, redear, pumpkinseed, green sunfish, panfish, etc.) found in overpopulated conditions may detract from overall lake or pond quality. Fish management is a continuous process that requires frequent monitoring.

Under certain conditions, fish management may entail use of special pesticides called **piscicides**, more commonly called fish toxicants. Fish management requires in-depth training and experience working with complex aquatic ecosystems. Commercial use of piscicides is a regulated activity classified under pesticide applicator certification category 5, aquatic pest management, according to the Michigan Pesticide Control Act 171. The Michigan Department of Natural Resources also regulates the application of piscicides by issuing permits for such treatments to waters of the state under Act 245 of 1929, the Water Resources Commission Act.

This chapter is intended to provide you with a basic knowledge of how and when to apply piscicides. These activities should be performed only by trained professional fisheries biologists with appropriate pesticide applicator credentials. All details and site-specific decisions required for a comprehensive and successful fish management program are not covered in this chapter. *"Managing Michigan Ponds for Sport Fishing," Second Edition*, Extension bulletin E-1554, produced by MSU Extension in cooperation with other agencies, is a useful manual for learning more about all the considerations required for successful pond management for fishing. Additional references are listed in Appendix A. For more information, contact the MDNR, a fisheries and wildlife specialist at MSU or a private fisheries consultant.

Stunted Fish

Stunted sunfish is a common problem in Michigan's inland ponds and lakes, though other fish may also be prone to stunting, such as bullheads, perch and crappie. To determine if sunfish are stunted, sample several and observe their length and/or the ages from scale samples and compare age to total length.

Determining Fish Age

Scales can be used to determine fish age for most species. A typical scale from a bluegill is shown in Figure 10-1. About 10 to 20 scales are removed with the blunt edge of a knife from the upper side of the fish, just under the front edge of the dorsal fin.

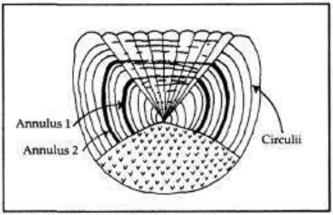


Figure 10-1. Fish scale showing annuli.

Place scales from individual fish in envelopes like those used by coin collectors. Record important information on the outside of the envelope, including the collector's name, the species of fish, the locality and method of capture, the date and time of capture, and the total length and weight of the fish. To obtain meaningful samples, you should sample at least 10 fish per inch group (i.e., ten 2- to 3-inch fish, ten 3- to 4-inch fish, ten 4- to 5-inch fish, etc), collected over a short period of time. Take samples to a trained fisheries biologist for evaluation.

The scales are generally aged on a microfiche reader. The scales are slightly moistened, placed on the microfiche reader and read directly off the screen. **The age of the fish is determined by counting the number of wide transparent growth rings, called annuli.** The bluegill in Figure 10-1 is 2 years old. Aging fish is similar to aging a tree by counting the number of growth rings.

Bony structures such as spines, vertebrae or otoliths (ear bones) can be used to age scaleless fish, such as catfish, or fish with very small scales, such as lake trout. These are cut into thin sections so the annuli on these structures can be read. This process should be done only by experienced fisheries biologists. Table 10-1 provides some information about various fish and approximate sizes at different ages.

If the bluegills are significantly smaller than the size listed for the appropriate age group in Table 10-2, they are stunted. If bluegill are stunted, their maximum size at any age would be 4.5 to 5.7 inches.

Stunting in bluegills or other sunfish types has two probable causes: either large predators are unavailable, or the sunfish are able to hide from the large predators in dense stands of weeds. Both allow the survival of large numbers of young sunfish that would normally be eaten by predators. Bass, the typical sunfish predators, are sight feeders. If the sunfish have dense weeds to hide in, it is very difficult for the bass to locate and capture them. Therefore, fisheries management includes aquatic vegetation management. Once the number of small sunfish increases dramatically, their growth rate slows as their food supply diminishes. They will reduce the number of young bass by raiding nests and eating the bass eggs and larvae. The result is fewer adult bass to prey on the sunfish, and increased stunting. If sunfish numbers are reduced, bass can quickly replenish themselves. Mature female bass can produce 10,000 to 20,000 eggs a year.

The stunted fish problem is a function of the carrying capacity of a lake or pond. A lake supports around 200 to 400 pounds per surface acre in southern Michigan. It doesn't matter if that is 200 one-pound fish or thousands of sunfish that weigh only a few ounces each. The more fish you have, the smaller the portion of the total food supply that each gets. Additional food is not a solution — it adds more nutrients to the system which promotes more weed growth.

	Length in inches						
	First summer	Second summer	Third summer	Fourth summer	Fifth summer	Sixth summer	Life expectancy
Kind of fish	**(Age 0)***	**(Yearling)**	**(2-yr-old)**	**(3-yr-old)**	**(4-yr-old)**	**(5-yr-old)**	
Rainbow trout**	4-6	9-14	14-171	5-19	***	***	5-7
Brook trout	2-4	6-8	8-12	9-14	11-16	***	5-7
Largemouth bass	1-4	6-8	8-10	10-12	12-14	13-17	14-15
Smallmouth bass	1-4	4-7	7-10	10-12	12-14	13-17	12-14
Channel catfish	1-4	5-7	8-10	11-13	13-15	15-17	10-14
Bluegill	.5-2	3-4	4-5	5-6	6-7	6.5-7.5	10-11

*Fingerling
**From fall-spawning stock in hatcheries.
***Very few survive to this age, and growth at this age is extremely variable.

Table 10-1. Summer length ranges at various ages for fishes in Michigan ponds. These are rough statewide values. Growth may be somewhat greater where fish are not crowded and temperature and food supply are ideal. Growth can be much slower, especially where ponds are overpopulated. (D.L. Garling and Keith Ashley, 1984, MSU Extension bulletin E-1774, "Determining the Age of Fish.")

Age (years)	1	2	3	4	5	6	7	8
Size (inches)	1.8	3.4	4.5	5.7	6.5	7.0	7.5	8.0

Table 10-2. The mean sizes of bluegills in our region (from MSU Extension bulletin E-1774).

As with aquatic weed control, understanding a lake's ecosystem is crucial. A fish biologist must select the correct fish species suitable for a given water body and recommend physical alterations to improve the conditions. Pond depth and surface area, water supply, water quality and water temperature must be determined when managing fish. The stunted fish problem requires a drastic reduction (about 90 to 95 percent) in the number of stunted sunfish. The conditions that led to the development of the stunted population must also be identified and corrected or the problem will reoccur.

Fish Population Management Tactics

There are a variety of reasons to reduce the fish population in a water body. It may have become contaminated with undesirable fish, such as carp, suckers or bullheads. A trout pond may contain unwanted warmwater fishes that are competing for food and reducing trout growth and survival. It may have suffered a winter-kill of one kind of fish but not others that disrupted the predator-prey balance. Or perhaps panfish are overabundant and stunted. Various methods to alter fish populations are described below.

1. Intensive angling

It is often thought that sunfish overabundance can be remedied by intensive fishing. Angling for reduction of sunfish, however, is rarely effective.

2. Predator stocking

It is often thought that stocking northern pike, muskellunge or walleye (predators) should result in sunfish control. Such attempts have been numerous but not successful. The stunted sunfish are too large to be consumed by predators in the sizes normally stocked. In addition, these predators would rather eat torpedo-shaped prey, such as small bass, than fish shaped like a sunfish.

Each northern pike or walleye requires 5 to 10 acres of lake area to support its feeding requirements. Pike and walleye should never be stocked in ponds or small lakes. Having northern pike in bass-bluegill ponds often results in more predation on bass than on bluegills.

3. Spawning bed destruction

Attempts have been made to control sunfish by destroying their eggs, by raking or trampling the nests. For this to be effective, however, almost every nest has to be destroyed. Sunfish spawn over such a long period, hatch in so few days and hatch so many fry (young fish) in each nest that such control measures are a long, hard task with a high failure rate.

4. Cover reduction

Sunfish can overpopulate a pond when plant cover is abundant. The weeds must be reduced or the problem will continue. Scattered stands with moderate plant density (about 80 stems per square yard or meter) promote a better balance between predator and prey fishes. Weeds can be reduced by physical, chemical, mechanical or biological means.

5. Water level drawdown

Some fish populations can be controlled by manipulating water level. When deciding if a drawdown should occur, consider the impacts it will have on all other components of that ecosystem. Review the "Nonchemical Aquatic Vegetation Management Techniques" (chapter 6) in this manual and consult with a lake vegetation manager to determine the impact on both the desirable and the undesirable plant species found in that water body. An Act 346 permit is required to drawdown the water body.

Water discharged from a water body must not damage downstream waters or properties by flooding, erosion or sedimentation. The owner is responsible for releasing the water in a cautious and reasonable manner.

Fish present in the pond may not be released into public waters without a permit from the MDNR Fisheries Division. Unauthorized introductions of fish can disrupt natural fish populations to the detriment of public interest.

Total drawdown is used to eliminate all fish from a pond. Do not overlook fish in residual puddles. Spot applications of fish toxicants may help in attaining complete kill. Desirable fish, such as large bass, can usually be salvaged and kept alive for restocking if other water for holding them is available.

Partial drawdown can be used to concentrate fish so the predators such as bass can feed more efficiently. This tactic depends on having enough predators to consume a large portion of the unwanted fish. When the pond refills, the survivors may be able to make better use of the existing food supply, if overabundant aquatic plants have been controlled.

Predatory reduction of small fishes will be most effective if the partial drawdown is done for a month or more in July or August. Carefully consider whether the danger of oxygen depletion and mass fish die-off will increase during partial drawdown.

6. Seining

Seining is often the most effective method for reducing numbers of unwanted fish in small ponds. Seining is usually done by two people, each holding a wooden upright that supports an end of the net. See figure 10-2. Floats keep the seine top at the water surface, and weights hold the bottom edge on the pond bed (See figure 10-3). For best results, the seine must be deeper than the deepest part of the pond so that it will "belly" without being pulled away from the pond bed as it is drawn along. The seine must stay tight along the pond bed or fish will escape underneath. Seines of 50 to 200 feet (15 to 60 meters) can be built to fit various ponds.

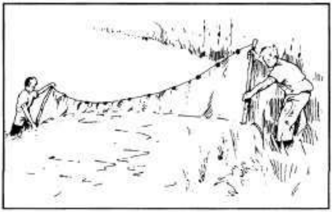


Figure 10-2. Seining a pond.

Small minnow seines of 15 to 40 feet (5 to 12 meters), available at sporting goods shops, can be used along shorelines to remove panfish fry (recently hatched fishes) and fingerlings (small fish up to one year in age). Small seines may be especially useful on panfish during spawning periods.

Nylon netting is most rip resistant and needs little maintenance. For removing small panfish, use netting with mesh of from 1/4 to 1/2 inch (1/2 to 1 cm).

The pond bottom should be smooth and free of snags such as rocks, logs and brush. Dense weed beds also impede seining. Water-level drawdown can aid in seining by drawing water away from weed beds and other shore-zone obstructions, as well as decreasing the area and depth to be seined.

Draw the seine so that the bottom edge stays ahead of the upper edge. Many fish escape if a seine rolls up at the bottom as it is pulled along.

To recover bass, large panfish or minnows and return them to the pond uninjured, pocket the seine in shallow water at the end of the haul rather than dragging it ashore. Rolling or folding the net can greatly harm fish by bruising them and by removing their slimy covering and scales, thus increasing the

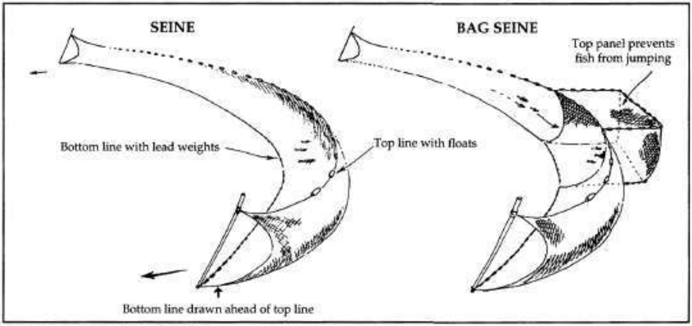


Figure 10-3. A seine and a bag seine.

risk of infection and disease. Minnows are very prone to such injury, especially in hot weather.

To thin out populations of bluegills and other sunfish, seine frequently in the warm season when continual hatching of sunfish occurs. Remove panfish that are less than 6 inches (15 cm) long, and return those over 6 inches plus any bass or channel catfish (not bullheads!). This amounts to selective breeding for the trait of fast growth, while making room for that growth to occur.

Continue seining until about 80 percent of the pond's estimated summer poundage of panfish has been removed. Estimating the total weight of panfish in a pond is difficult, and it is best to consult a professionally trained biologist in your area.

Seining can provide useful information about the fish population but can also give misleading impressions. Bass and carp, especially the older ones, are skillful at avoiding nets. When you seine up only small bass or carp, don't conclude that the big ones aren't there.

7. **Live Trapping**

Fish traps may be useful for reducing populations where obstacles to seining are present. An effective trap can be made of 1/2-inch (1-cm) hardware cloth on wooden framing. Figure 10-4 illustrates three types of fish trap construction.

Use traps with or without "wings," which are like fences extending outward from the mouth of the trap. They guide fish toward the opening.

Place traps in water that is just deep enough to cover them, parallel or at right angles to the shore, off peninsulas or in shallow bays where small fish gather. Support traps with poles or iron reinforcing rods driven into the bed. Up to 10 traps per acre (25 per hectare) may be needed.

For panfish thinning, remove the same amounts and sizes of fish as described in the section on seining. Take fish out of traps daily. Otherwise, turtles may be attracted and eat the desirable fish.

Gauze bags of bait, such as bread, oatmeal, soybean cake or cottage cheese can be hung in traps to increase catch, but they aren't necessary.

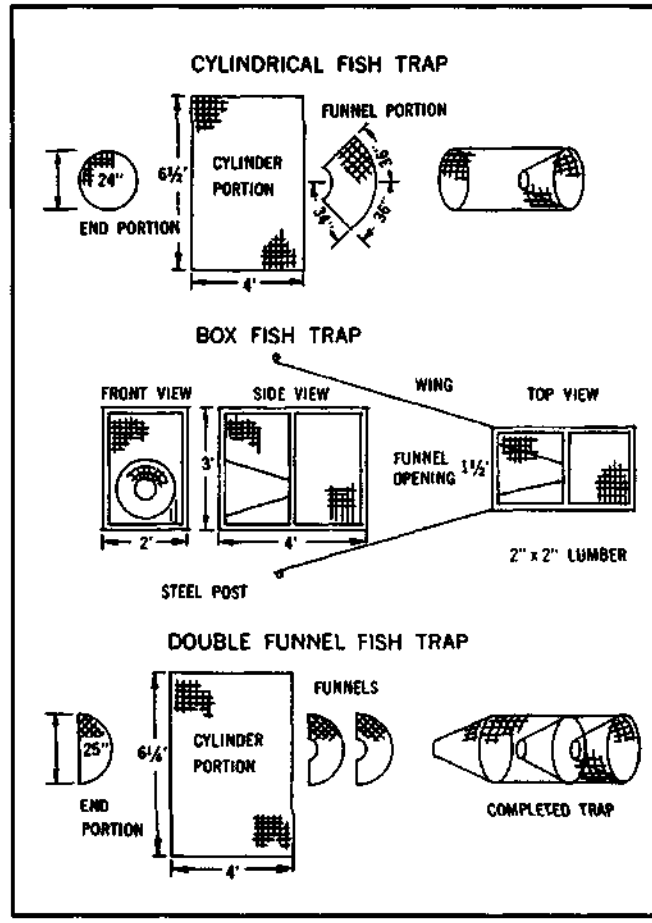


Figure 10-4. Fish trap construction.

Fish Management Using Piscicides

Mechanical techniques to remove fish, such as seining and trapping, can be effective but have limitations. Piscicides have become important in fish management because they may overcome some of these limitations. Before attempting any piscicide application, consult a specialist from the MDNR or MSU Extension who has ample experience working with these compounds. A DNR permit is required under the Water Quality Act, Act 245 (P.A. 1929), which requires permits to "regulate the discharge or storage of any substance which may affect the water quality of the State."

Preparing for a Piscicide Treatment

Only two piscicides are registered for fishery use by the U.S. Environmental Protection Agency.

Be familiar with label directions and Material Safety Data Sheets (MSDS) for each product. Follow all product label directions. Have copies of the labels and MSDSs for the products available for reference as follows:

— When products are handled and transported.

— Where products are stored.

— Where products are used.

Use all safety equipment as defined on the label when handling piscicides, oxidizers and dyes.

Follow all storage guidelines as discussed in the core manual, E-2195, chapter 6, "Pesticide Handling, Storage and Disposal." To avoid storage complications, purchase products at the time of need and purchase only the quantity to be used for each treatment. Some formulations may separate when subjected to freezing temperatures, so mix well before applying. Some piscicides lose solvents (the carrier or liquid that dissolves a pesticide to form a solution), even in unopened containers. The contents may dry to a crystalline substance if stored for an extended period of time.

When preparing for a treatment, comply with the Michigan Pesticide Control Act, Public Act 171 of 1976, the Public Health Code, Act 368 of 1978, Act 346 of 1972, the Inland Lakes and Streams Act and Act 245 of 1929, the Water Resources Commission. Obtain all necessary certifications and permits. (See the chapter on laws and regulations in this manual.) Plan for the containment and neutralization (pesticide degradation) strategies that accompany your treatment. Contain treated water until it is neutralized whenever possible. If containment is not possible:

— The area required for neutralization should be accounted for in the treatment plans.

— Neutralization is to be completed in a manner so that no fish are killed outside the described project area.

A piscicide applied to water can be neutralized by natural degradation, dilution and/or detoxification. When considering the rate of neutralization of treated waters, consider the following factors:

- — Volume of inflow to the treatment zone.
- — Tributaries.
- — Volume of outflow.
- — Temperature.
- — Turbidity.
- — Chemical and biochemical oxygen demand.
- — Species composition.
- — Profile of water velocities across a stream channel.
- — Dilution.

Toxic effects of piscicides can be eliminated almost immediately with potassium permanganate ($KMnO_4$), a strong oxidizing agent with biocidal properties. $KMnO_4$ is used to control fish diseases, eliminate taste problems in fish, reduce algal blooms and detoxify fish toxicants. Piscicide applicators may use $KMnO_4$ to set up borders in a lake, for example, where no toxicant is wanted. A cold or muddy stream or lake will require more $KMnO_4$ to neutralize a toxicant. Cold water will slow the rate of reaction, and muddy water has more organic matter that will bind with the $KMnO_4$ and make it less available. Contact the MDNR Fisheries Division for assistance in planning for and determining detoxification procedures and rates.

If $KMnO_4$ is used to detoxify water, the piscicide solvents and emulsifiers (chemical that allows petroleum-based pesticides to mix with water) may be removed by other chemical agents. Activated carbon filtration can remove the solvents, emulsifiers and any odor caused by the piscicide.

Potassium permanganate is toxic to some fish, and concentrations of 3 to 4 milligrams per liter are hazardous to apply. Use nose, throat, and eye protection when handling or working with $KMnO_4$. If the compound is accidentally taken internally, give the person lemon juice or orange juice, milk or a sugar solution to drink. If none of those are available, give large quantities of water. See chapter 5, "Pesticides and Human Health" in the core manual, E-2195, for more information on pesticide exposure.

When treating water bodies with an outlet and water control structure (e.g., valve or stoplogs):

- — Lower the water level as much as possible before treatment.
- — Shut off the outflow to the extent possible during treatment.
- — Contain treated water within the project area until it is neutralized or detoxified.

When treating water bodies with outlets but no water control structure:

- — Determine containment or neutralization measures on an individual basis.
- — Neutralize treated water (see above) before it leaves the project area.

Methods of Application

Uniform distribution of a fish toxicant in a body of water is essential. Depending on circumstances, various methods can be used.

Backpack sprayers may be useful for treating small ponds. They can also be used to cover marshy areas and shorelines with thick vegetation. Failure

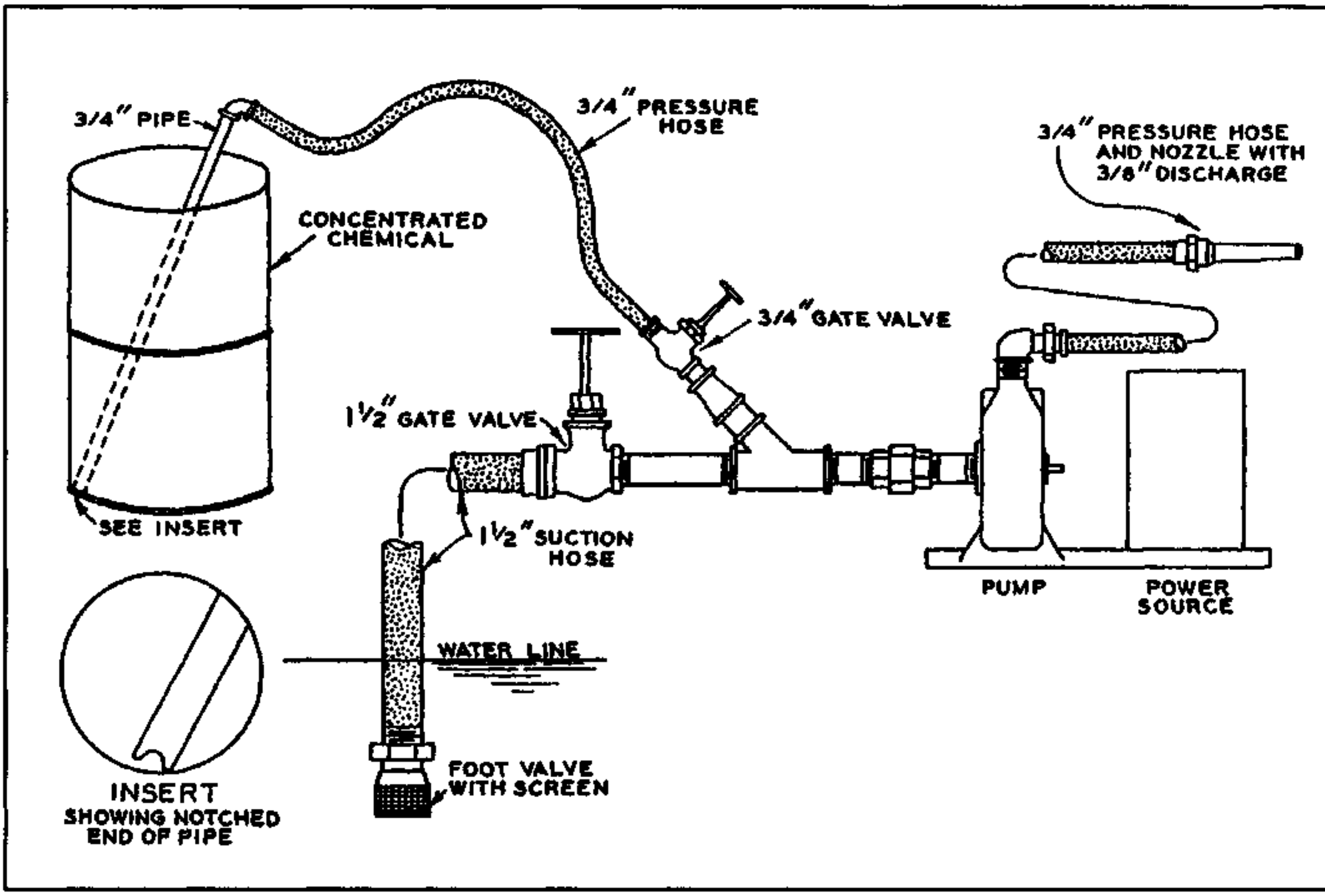


Figure 10-5. Equipment for chemical treatment of lakes. Modified from drawing furnished to the MDNR by Wisconsin Committee on Water Pollution.

to cover these areas adequately may cause the entire project to fail.

Motor-driven boats are used for large ponds and lakes. Spray the surface and along the edges with a centrifugal pump with enough pressure to throw a stream of water 30 to 40 feet. Dilute the piscicide according to the manufacturer's directions before spraying it on water. This dilution prevents waste or excessive application of material. To dilute the chemical, connect the pump intake to a 45 degree wye (shape of a "Y"). A hose from one arm of the wye draws chemical from a reservoir in the boat, while the other arm of the wye is connected to a hose through which diluting water is drawn from the lake. Valves on these two lines control the proportions of dilution water and chemical. See Figure 10-5.

For deep-water treatments in large lakes, a venturi rig is effective in dispersing the chemical. A boat bailer can be attached to the lower unit of an outboard motor and to a 30- to 55-gallon graduated tank in the boat by a length of hose. With this rig, chemical is siphoned from the tank at an even rate if the boat speed is constant. A faucet attached between the hose and the tank regulates the dispersion of toxicant. (See Figure 10-6.) Review the "Pesticide Application Equipment and Techniques" chapter in this manual.

Chemicals can be dispersed into water below the thermocline (the division between the layer of warmer water above the cooler water below) by attaching a heavy metal pipe or weights to the discharge hose. Even at slow running speeds, a 20- to 30-pound weight may need to be attached to the pipe. You can check the depth of the pipe while running by towing it toward shore until it strikes the bottom and taking a depth sounding at this point. This gives the approximate depth at which the chemical is being distributed at a given running speed.

To get even distribution of chemical over the surface of a large lake, subdivide the lake into sections and apply a quantity of chemical that is proportional to the volume of each section. Mark these sections in advance with shore markers and buoys. Because the quantity of chemical to be applied to a given area must be proportional to its volume, deeper areas are usually traversed with venturi rigs more than once, while shallow shore zones are sprayed once. An orderly pattern for applying the chemical is necessary.

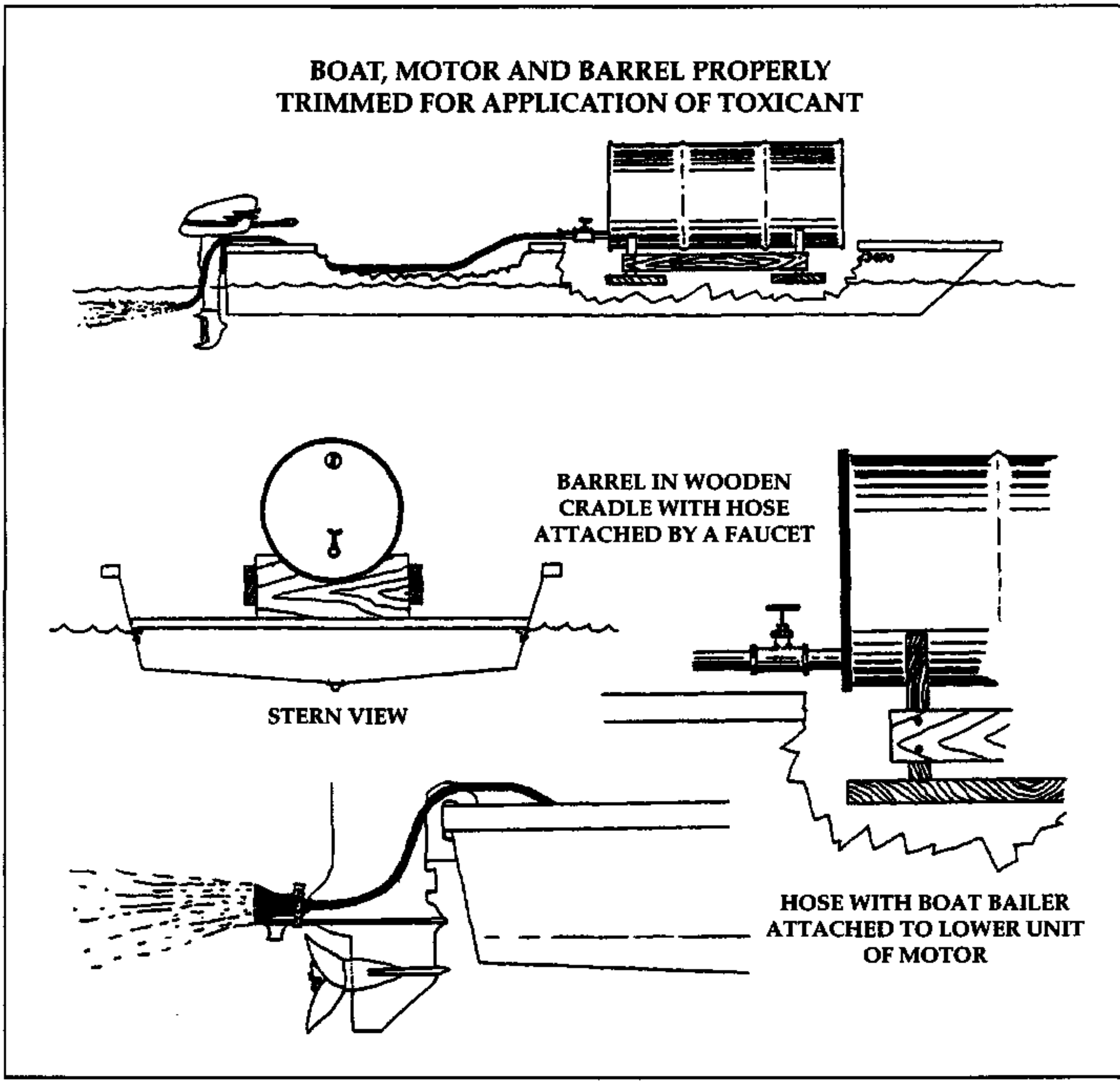


Figure 10-6. "Venturi rig" for applying liquid fish toxicants.

For small lakes, a spiral treatment pattern with a venturi rig may be the most efficient. Treatments start from shore and proceed toward the center in a spiral pattern. The distance between successive whorls should not exceed 30 feet. This is necessary for thorough coverage because wind and wave action does not carry chemical effectively to all water areas.

Because of the complex nature of flowing waters, applications to streams, irrigation ditches or other flowing water require professional planning and implementation.

Flowing waters may require continuous introduction of toxicant from one or more stations for a period of time. Effective treatment of flowing water systems depends on several factors, including:

- Chemical concentration (calculate volume of area being treated to determine dose).
- Contact time (determine flow rate in cubic feet per second).
- Type of target fish.
- Water temperature (colder water temperatures may reduce effectiveness of piscicides).
- Water turbidity and pH.
- Weather conditions.

Piscicides

Piscicides work by interfering with fish cellular respiration. Piscicides are generally nontoxic to most mammals and birds at the concentrations used to kill fish, but swine may be adversely affected. Some piscicides leave a detectable taste or odor for up to a month after water is treated. Taste and odor can be removed immediately by treating the water with activated charcoal at a rate of 300 parts per million for each 1 part per million piscicide remaining.

Piscicide toxicity is influenced by species, size of fish, water temperature, pH and oxygen concentration, the presence of suspended matter in the water, sunlight, and metabolic activity of aquatic organisms.

Concentrations of piscicides lethal to fish will not harm submersed or emergent aquatic vegetation. The presence of aquatic plants can interfere with application, however, and reduce the efficacy of fish toxicants. If masses of floating plants are present, the toxicant should be distributed under the floating masses. To avoid this placement problem due to the presence of aquatic plants, treat in the fall after plants have died back. Be aware that piscicides can last longer in the cool water that's typical of fall or spring conditions.

Silt can adsorb toxicants, thereby reducing their effective concentration.

In thermally stratified lakes, some toxicant solutions do not penetrate the thermocline. This can be an advantage if the intent is to remove the warm-water species and cold-water species remain in the lower, colder depths where the piscicide may not penetrate. This separation of zones based on temperature cannot be relied on completely to protect nontarget species because some cold-water species forage in the upper zones where they are exposed to piscicides. Also, some cold-water species are diurnal and move into the upper zones at night. Warm-water species can also move out of the treated area by moving into lower, colder zones, thereby avoiding lethal concentrations.

Piscicides are photochemically degraded, so if sunny weather is predicted, applications should be made early in the morning or late in the day to allow time for a reaction.

Fish Sensitivity to Piscicides

Through research experiments and observation, biologists have divided fish species into three groups with high, moderate and low sensitivity to piscicides. In general, scaled fish are more sensi-

Least resistant (Most susceptible)	Moderately resistant (Moderately susceptible)	Most resistant (Least susceptible)
Gizzard shad	Bigmouth buffalo	Black bullhead
Minnows	Black crappie	Bowfin
Trout	Bluegill	Channel catfish
Walleye	Brook stickleback	Flathead catfish
Yellow perch	Carp	Goldfish
	Fathead minnow	Shortnose gar
	Freshwater drum	White catfish
	Largemouth bass	
	Northern pike	
	Northern redbelly dace	
	Quillback	
	Smallmouth bass	
	Spotted sucker	
	Sunfish	
	White crappie	
	White sucker	

Listing within groups is in alphabetical order.

Table 10-3. Relative Resistance of Fishes to Piscicides (Adapted from Illinois Pesticide Applicator Training Manual 39-6, Aquatics, 1989).

tive than bullheads or other catfish, sunfish are moderately sensitive, and species such as yellow perch and trout are highly sensitive to piscicides.

The duration of fish exposure to a lethal dose of piscicide — contact time — is a critical factor. In streams a chemical can move past the fish, and in standing bodies of water rapid dilution or degradation is likely. Fish must receive a lethal dose before the fish or the toxicant moves from the treated area.

If the water body has outlets, it is important that the application method does not repel the fish. Understand the properties of the product you select. One piscicide currently registered by EPA repels fish. If you use this product, close off all known outlets so the fish do not escape before receiving a lethal dose. An alternative is to use a different product. If these outlets are creeks or streams, treatment effects may be short-term because fish will be able to reenter the area. Treatments should not be attempted without proper authorization and experienced applicators. Develop an acceptable plan for disposing of the dead fish before making a treatment. Digging pits and burying them deep enough so that raccoons and other fish-eating animals cannot get to them may be an option. Burying the fish lessens the stench that accompanies fish decay. Use of approved landfills in the area of your treatment is most likely required to dispose of dead fish. The MDNR is exploring a method for composting dead fish. Check with local authorities for proper disposal procedures.

Lampreys (Primitive Vertebrates): a Problem to Great Lakes Fish

Four native lamprey species occur in Michigan, along with one species, the sea lamprey, that is not indigenous. Sea lampreys are considered pests in Michigan waters. Sea lampreys are native to the Atlantic Ocean. They were introduced to the Great Lakes beginning in the late 1880s with the completion of the Erie and Welland canals. Food supplies were abundant and stream conditions ideal for reproduction and survival. By 1938, sea lampreys were present in all five of the Great Lakes.

The sea lamprey is considered a pest because, in its lifetime, a single sea lamprey can kill 40 or more pounds of fish by attaching to the fish with its sucking disk and horny teeth and using its sharp tongue to rasp through scales and skin to feed on fish body fluids. To kill large fish such as salmon and lake trout usually takes more than one attack by a sea lamprey. Several attacks will weaken the fish and ultimately kill it.

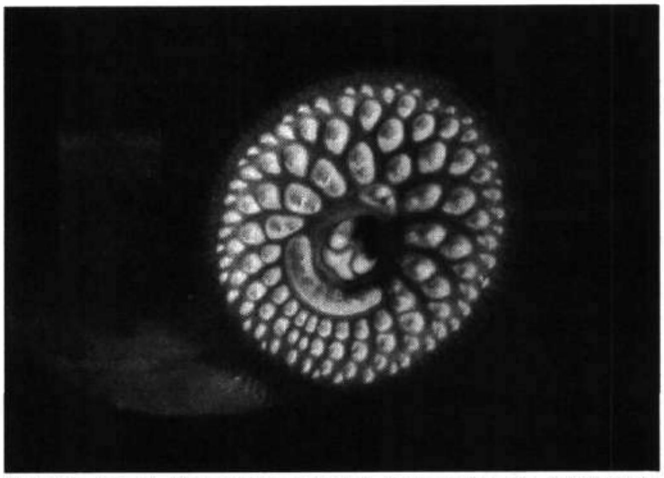


Figure 10-7. "Sea lampreys' horny teeth." Credit: Michigan Sea Grant Program.

The sea lamprey was a major cause of the severe reduction in populations of lake trout, whitefish and other desirable and commercially valuable fish in the Great Lakes during the 1940s and 1950s. Today fish populations are abundant and

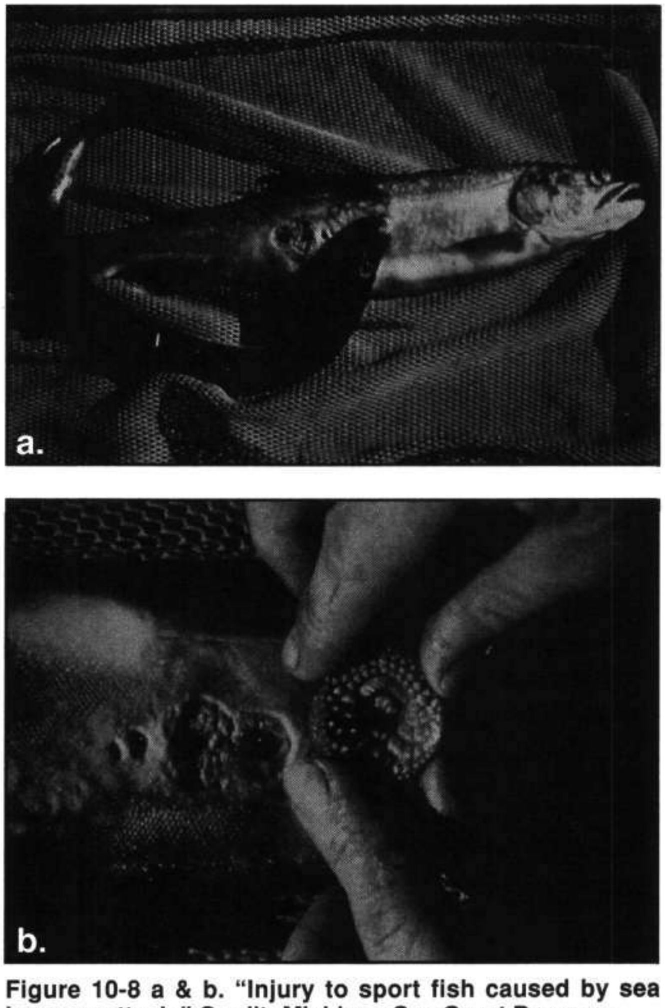


Figure 10-8 a & b. "Injury to sport fish caused by sea lamprey attack." Credit: Michigan Sea Grant Program.

the Great Lakes again rank high as a source of recreational and commercial fisheries. This revival can be directly attributed to the international sea lamprey management program.

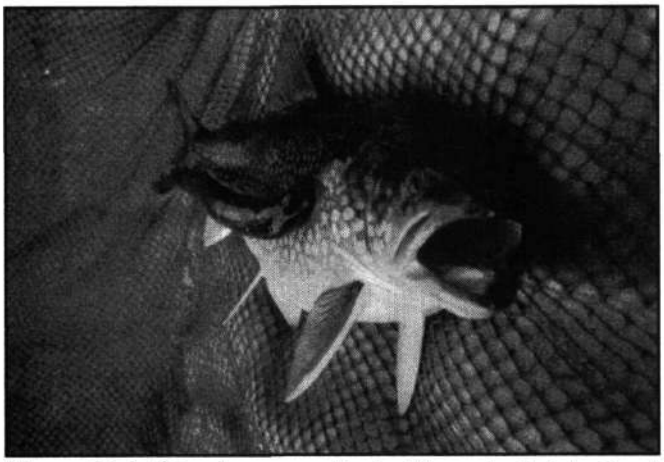


Figure 10-9. "Sea lamprey attached to a desirable Great Lakes fish." Credit: Michigan Sea Grant Program.

Aquatic pest managers are not involved in sea lamprey management because control programs are administered only by governmental agencies. The Great Lakes Fishery Commission funds the Sea Lamprey Control Program for American waters. The cooperating agencies in Canada include the Department of Fisheries and Oceans and the Ontario Ministry of Natural Resources. The U.S. Fish and Wildlife Service contracts with the Great Lakes Fishery Commission and implements the control procedures for the United States.

If you encounter a lamprey population or receive inquiries, contact the U.S. Fish and Wildlife Service sea lamprey control unit.

Piscicide Calculations

Work through the following equations to familiarize yourself with calculating appropriate rates for treatments associated with fish management. Calculations for piscicide applications to flowing water and standing water follow. You will not be responsible for knowing the constants and how they are derived, but you do need to have a working knowledge of the equations.

Standing Water Example: Piscicide Application

1. Obtain all appropriate permits and certification.
2. After identifying the species that needs to be eradicated, determine the amount of piscicide needed to apply to standing water when the recommended label rate is 3 ppm, the effective contact time (ECT) is 10 minutes (determined by species susceptibility to the piscicide) and the pond is 100 feet by 75 feet by 4 feet average depth.

> Constants (conversion factors) needed for this equation:
>
> - 43,560 cubic feet/acre foot
> - 0.329 gallons of piscicide/acre foot/ppm
> - 3,785 ml per gallon

Determine the volume of the pond in acre feet:

$$= \frac{\text{length x width x average depth}}{\text{43,560 cubic feet/acre foot}}$$

$$= \frac{\text{100 ft. x 75 ft. x 4 ft.}}{\text{43,560 cubic feet/acre foot}}$$

= 0.689 acre feet

Determine the gallons of piscicide needed for a 3 ppm application:

= Acre feet to be treated x 0.329 gallons piscicide/acre foot/ppm x desired ppm

= 0.689 acre feet x 0.329 gallons piscicide/acre foot/ppm x 3 ppm

= 0.68 gallon

Determine the milliliters of piscicide to add to sprayer (convert gallons to ml):

= 0.68 gal. x 3,785 ml/gal.

= 2,551.09 ml

3. Determine the pumping rate of your sprayer in gallons per minute (GPM).

   Use 0.22 GPM for this example.

4. Determine the output of the spray tank when making this 10 minute (10 ECT) application.

   = Duration of treatment (ECT) x pumping rate (GPM)

   = 10 ECT (min) x 0.22 GPM

   = 2.2 gallons of output

Convert gallons of solution to ml:

= 2.2 gallons x 3,785 ml/gallon

= 8,327 ml solution

Determine the amount of water to be added to the spray tank:

= Total solution in sprayer – Amount of piscicide

= 8,327 ml of total solution – 2,573.8 ml piscicide

= 5,753.2 ml water

Potassium Permanganate ($KMnO_4$)

If you need to apply $KMnO_4$ to detoxify a piscicide application, use the following calculations:

Constants needed:
- 453.5 grams per pound
- 16 ounces per pound
- grams = milliliters

1. Determine clarity and water temperature values.

Clarity values		Water temperature values		
Clear	1.00	Hot	(> 30°F)	1.00
Turbid	1.25	Warm	(24° to 29°)	1.25
Muddy	1.50	Cold	(18° to 23°)	1.50

2. Determine the multiplier value if you are applying $KMnO_4$ to turbid, hot water.

Multiplier value = (clarity value) + (temperature value)

= 1.25 + 1.00

= 2.25

3. Determine pounds of $KMnO_4$ needed to detoxify the 2551.09 ml of piscicide you added in the standing water example.

$$\text{Grams of } KMnO_4 = \frac{2551.09 \text{ ml} \times 2.25}{29.573 \text{ ml/ounce}}$$

= 86.26 ounces x 2.25

= 194 ounces + 16 ounces/lb

= 12.13 lbs.

As a general rule, the MDNR finds that 5 ppm of $KMnO_4$ detoxifies 3 ppm of the piscicide rotenone.

Marker Dye

Often a marker dye is used to determine where the piscicide has been added in flowing water. The dye, sprayed before the piscicide application, enables the applicator to know where to apply the detoxicant, if needed.

Flowing Water Example: Piscicide Application

1. Obtain all appropriate permits and certification.

2. Determine the estimated discharge rate of the stream in cubic feet per second (CFS). Refer to Chapter 8, "Pesticide Application Equipment and Techniques" in this manual.

   Set barrier nets above and at the end of the treatment section and mixing section of the stream being treated.

Constants (conversion factors) needed for this calculation:
1.7 ml/min/CFS/ppm of piscicide product
3,785 ml/gallon

3. Determine the amount of piscicide needed to apply per minute to the flowing water when the recommended rate of product is 4 parts per million (ppm) for 10 minutes ECT, and the discharge rate is 26.49 cubic feet per second (CFS).

   ml product/minute

   = discharge rate x 1.7 ml/min/CFS/ppm x rate of application

   = 26.49 CFS x 1.7.ml/min CFS/ppm x 4 ppm

   = 180.13 ml/min.

   Total ml product = ml product/min x min ECT

   = 180.13 ml/min x 10 min ECT

   = 1801.3 ml piscicide

4. Determine the pumping rate of your sprayer in gallons per minute (GPM). Use 0.22 GPM for this example.

5. Determine the output of the spray tank when making this 10 minute (10 ECT) application.

   = Duration of treatment (ECT) x pumping rate (GPM)

   = 10 ECT (min) x 0.22 GPM

   = 2.2 gallons output.

   Convert gallons of solution to ml:

   = 2.2 gallons x 3,785 ml/gallon

   = 8,327 ml of solution.

Determine the amount of water to be added to the spray tank:

= Total solution (ml) in sprayer – Amount of piscicide (ml)

= 8,327 ml – 1801.3 ml piscicide

= 6525.7 ml water to add to tank.

Detoxification with $KMnO_4$

Calculate the amount of potassium permanganate ($KMnO_4$) needed to detoxify the piscicide application. Starting at the end of the treatment zone on the stream, the MDNR generally detoxifies for a period of time before and after the application time. In the above flowing water example, calculate for 10 minutes before, during and 10 minutes after the treatment has reached and passed through the mixing zone (the end of the treated area).

As a general rule, the MDNR finds that 5 ppm of $KMnO_4$ detoxifies 3 ppm of the piscicide rotenone.

Then 4 ppm rotenone is detoxified with 6.67 ppm $KMnO_4$.

Conversion factor = 1.7 g/minute/CFS/ppm product

Note: gram = cc = ml water

Determine application rate of $KMnO_4$ g/min:

= Discharge rate (CFS) x 1.7g/min/CFS/ppm x Desired ppm

= 26.49 CFS x 1.7 g/min/CFS/ppm x 6.67 ppm

= 300.37 g/min

Determine total grams of $KMnO_4$ needed for duration of application:

= Application rate g/min x (10 min before + 10 min during + 10 min after)

= 300.37 g/min x (10 min + 10 min + 10 min)

= 9,011.1 g

Drip System Piscicide Calculation, Calibration and Worksheet

The following can be used as a standard step-by-step procedure for setting up picicide drip systems along a flowing stream to ensure sufficient contact time at the specific labeled rates.

For this example we will use the following data:

County drain length to be treated = 2 miles = 10,560 ft.

Average width = 10 ft.

Average depth = 4 ft.

Flow rate = 20 cfs (cubic feet per second)

60 seconds x 60 minutes = 3600 seconds per hour

Label Dose Rate = 1.7 ml/cfs/min

Step 1 – Calculate county drain volume.

Calculate stream volume in cubic feet based on water levels at the time of treatment by using the following formula:

County drain length (ft) x Avg. width (ft) x Avg. depth (ft) = cubic feet of water.

10,560 ft. x 10 ft. x 4 ft. = 422,400 cubic ft.

Step 2 – Calculate turnover time.

Calculate the amount of time it takes for the water in the stream to be replaced by new water, based on water flow rate at the time of treatment using the following formula:

$$\frac{\text{County drain volume (cubic feet)} \div \text{Flow rate (CFS)}}{3{,}600 \text{ sec/hr}} = \text{Turnover time in hours}$$

$$\frac{422{,}400 \text{ cubic feet} \div 20 \text{ CFS}}{3{,}600 \text{ sec/hr}} = 5.8 \text{ hrs}$$

Step 3 – Calculate total piscicide requirements.

Determine the amount of piscicide required to achieve a 1 ppm level with the volume of the stream.

First, convert the label dosage rate from (ml/cfs/min) to (ml/cfs/hour) since the turnover time of the flowing water is in hours:

= Label dosage rate (ml/CFS/min) x 60 min/hour

= 1.7 ml/CFS/min x 60 min/hour

= 102 ml/CFS/hour

Now, determine the total amount of piscicide required for treating this flowing water:

= Label dosage rate (ml/cfs/hr) x Flow rate (CFS) x Turnover time

= 102 ml/CFS/hour x 20 (CFS) x 5.8 hrs

= 11,832 ml piscicide.

To convert ml of piscicide into gallons of piscicide:

= ml piscicide ÷ 3,785 ml/gallons

= 11,832 ml ÷ 3,785 ml/gallons

= 3.1 gallons.

Step 4 – Number and distance between drip sites.

Determine the number of drip sites required

Turnover time (hrs)	Number of drip sites
Less than 4.5	1
4.6 – 7.5	2
7.6 – 10.5	3
10.6 – 13.5	4
13.6 – 16.5	5
etc.	

based on the turnover time (hrs) by using the chart below:

Based on a turnover time of 5.8 hours, calculated in step 3, the chart indicates that two drip systems are required.

Therefore:

$\frac{10{,}560 \text{ ft.}}{2}$ = 5,280 ft. between drip systems (place one system at the head of the county drain & measure 5,280 ft. downstream)

Step 5 – Calculate piscicide required for each drip site.

Calculate as follows:

$$\frac{\text{Total piscicide required (gal)}}{\text{No. of drip sites}} = \text{piscicide product required at each site (gallons)}$$

$$\frac{3.1 \text{ gal}}{2 \text{ sites}} = 1.55 \text{ gal/site}$$

Step 6 – Drip duration per site.

Based on the labeled dosage rate of 1.7 ml of pesticide per cfs per minute, determine the amount of drip time required for application at each site using the following formula:

$$\frac{\text{Piscicide required per site (gal)} \times 3765 \text{ ml/gal}}{\text{Label rate ml/cfs/min} \times 60 \text{ min/hr} \times \text{flow rate (cfs)}} = \text{Drip duration (hrs) per site}$$

$$\frac{1.55 \text{ gal X } 3785 \text{ ml/gal}}{1.7 \text{ ml/cfs/min x } 60 \text{ min/hr x } 20 \text{ cfs}} = \frac{5{,}866.75 \text{ ml}}{2{,}040 \text{ ml/hr}} = 2.87 \text{ hr}$$

Step 7 – Drip rate conversion and calibration.

To determine the drip rate in ml per minute, use the following formula:

Flow Rate (cfs) x Drip rate (ml/cfs/min) = Drip rate in ml/min

20 cfs x 1.7 ml/cfs/min = 34.0 ml/min

Conclusion and Explanation

Based on the example used, this county drain would be treated with two drip systems 5,280 feet (1 mile) apart. Each would be supplied with 1.55 gallons of product to be applied simultaneously at a rate of 34 ml/min. Treatment would take 2.86 hours. Suitable contact time is ensured but piscicide levels within any section of the drain would not exceed 1 ppm.

Similar calculations would be required for detoxification of the product and for use of marker dye.

Always read and follow all directions and precautions on the product label.

Chapter 10 – Fish Management Review Questions

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

1. Pesticides used for the purpose of killing fish are called ______________________.

2. The age of a catfish can be determined by counting the number of annuli — thick growth rings— on their scales. True or False?

3. What are the two probable causes of stunting of bluegills or other sunfish?

   1.

   2.

4. Which statement concerning seining is incorrect?

   a. Nylon netting from 1/4 to 1/2 inch is best for removing small panfish.

   b. The pond bottom should be smooth and free of snags and dense weeds.

   c. Seining should be done frequently in the warm season to be effective.

   d. Both a and c.

   e. None of the above.

5. Fish traps may be useful for reducing populations in ponds that have obstacles to seining. True or False?

6. List the three occasions when you should have available copies of the labels and MSDS for the pesticides being used.

   1.

   2.

   3.

7. A piscicide applied to water can be neutralized by:

   a. Dilution.

   b. Natural degradation.

   c. Detoxification.

   d. Both b and c.

   e. All of the above.

8. List six of the nine factors that must be taken into account when considering the rate of neutralization.

   1.

   2.

   3.

   4.

   5.

   6.

9. For a large pond, the surface and the edges can be sprayed with a centrifugal pump having enough pressure to throw a stream of water 30 to 40 feet. True or False?

10. Effective treatment of flowing water systems is dependent upon several factors including:

    1.

    2.

    3.

    4.

    5.

    6.

11. The fish least susceptible to piscicides is:

    a. Black crappie.

    b. Trout.

    c. Black bullhead.

    d. White sucker.

12. Black bullhead need to be removed from a pond that is 200 feet long, 80 feet wide and has an average depth of 5 feet. A piscicide concentration of 3 ppm for 15 minutes (ECT) is required for an effective treatment of bullhead.

    a. Determine the volume of the pond in acre feet of water and how much piscicide product is required to obtain a 3 ppm concentration. There are 43,560 cubic feet per acre foot of water.

    b. Next, determine how much water should be added to the spray tank if the sprayer has a pumping rate of .25 GPM.

13. Use the following data to solve the following questions.

Canal to be treated = 1.5 miles = 7,920 feet

Average width = 15 feet

Average depth = 5 feet

Flow rate = 20 cfs (cubic feet per second)

60 seconds x 60 minutes = 3,600 seconds per hour

Label dose rate = 1.5 ml/cfs/min

Step 1 – Calculate the volume of the canal as cubic feet of water.

length x avg. width x avg. depth = volume (cubic feet)

Step 2 – Calculate the canal turnover time.

$$\frac{\text{Volume of canal (cu ft.)} \div \text{Flow rate (cfs)}}{\text{3,600 seconds/hour}} =$$

Step 3 – Determine the amount of piscicide required to achieve a 1 ppm concentration in the canal. First, convert the label dosage rate from (ml/cfs/min) to (ml/cfs/hour) since the turnover time of the flowing water is in hours:

Label dosage rate (ml/CFS/min) x 60 min/hour.

Next, determine the total amount of piscicide required for treating this flowing water:

= Label dosage rate (ml/cfs/hr) x Flow rate (cfs) x Turnover time

Convert ml of pisicide to gallons of piscicide:
= ml piscicide ÷ 3,785 ml/gallon

Step 4 – Determine the number of drip sites and the distance between the drip sites.

Turnover time (hrs)	Number of drip sites
Less than 4.5	1
4.6 – 7.5	2
7.6 – 10.5	3
10.6 – 13.5	4
13.6 – 16.5	5
etc.	

$$\frac{\text{Length of canal}}{\text{\# of drip sites}} =$$

Step 5 – Calculate the amount of piscicide required for each drip site.

$$\frac{\text{Total piscicide required (gal)}}{\text{No. of drip sites}} = \text{piscicide product required at each site (gal)}$$

Step 6 – Determine the duration of the drip application at each site.

$$\frac{\text{Piscicide required per site (gal)} \times \text{3785 ml/gal}}{\text{Label rate ml/cfs/min} \times \text{60 min/hr} \times \text{flow rate (cfs)}} = \text{Drip duration (hrs) per site}$$

Step 7 – Determine the drip rate in ml per minute using the following formula:

Flow Rate (cfs) x Drip rate (ml/cfs/min)

= Drip rate in ml/min

CHAPTER 11

INVERTEBRATES

The trained aquatic pest manager may identify several species of animals in aquatic environments. Accurate identification and an understanding of the overall health and desired conditions for each water body will help pest managers determine whether an animal, by its presence alone is a pest, or if the levels and condition of the animal's population cause it to be a pest.

Invertebrates are a class of animals that lack a spinal column and are important links in aquatic food chains. Typical aquatic invertebrates include worms, leeches, water fleas, insect larvae, snails and mussels. An aquatic pest manager must be familiar with invertebrates that are considered undesirable in certain aquatic situations and the impact of herbicide treatments on invertebrates.

Aquatic herbicides are used to reduce, remove or eliminate nuisance aquatic macrophytes (plant life large enough to be observed with the naked eye) or algae. Herbicide rates are selected for their toxicity to aquatic plants or algae but may also affect other aquatic life. Most aquatic herbicides are not toxic to aquatic invertebrates when used at or below the labeled rates. When toxic effects are found, the impacts are usually short-lived because the high reproductive rates of most invertebrates allow populations to return to normal quickly. Indirect impacts may be equally important.

A properly administered herbicide treatment will result in decaying plant material. Decomposition may reduce the amount of dissolved oxygen in the water and this may decrease the number of invertebrates. The increase in decaying organic material may also increase the amount of food for invertebrates, which may increase their numbers. Weed control may also affect cover, and loss of cover may reduce their numbers. Usually a treatment results in more individual invertebrates but fewer species. The remaining species are likely to be those tolerant of lower water quality, and this shift may be undesirable.

As an aquatic pest manager, you must monitor the impacts of your management strategies. High quality aquatic environments are usually characterized by a high diversity of species and low numbers of each type.

Mollusks

Mollusks are invertebrates with soft unsegmented bodies usually enclosed in shells. Snails and freshwater clams (mussels) are members of this group.

Snails

Snails and certain aquatic birds are carriers of a minute, free-swimming parasite larva that burrows into and may irritate human skin. This phenomenon, referred to as swimmer's itch, is more common in the northwestern portion of Michigan's Lower Peninsula than in other locations of Michigan. One method of controlling swimmer's itch entails managing the snails that are hosts for the swimmer's itch larvae. Most snails do not carry the swimmer's itch larvae, so the mere presence of snails is not sufficient to justify a management treatment. Management alternatives have varying impacts on other plants and animals in the aquatic environment. To control larvae-carrying snails with the least harm to fish populations, be sure the snails present are the swimmer's itch larvae host. Then remove the snails' habitat: algae, plants and benthic (bottom) debris.

A specific drug treatment (Praziquantel) for birds infested with the swimmer's itch parasite is under study. Birds that carry the parasite are vaccinated to prevent them from spreading the problem around the lake or to other lakes. Current observations and results suggest that this drug treatment for birds may be an acceptable and effective practice for managing swimmer's itch in the future.

Mussels

Michigan waters have a newly introduced mussel pest — the zebra mussel. The first zebra mussel appearance occurred in 1985 in lakes St. Clair and Erie. It took only four years to spread to all of the Great Lakes. To date the zebra mussel has negatively affected the ecosystem, industry and recreation associated with these aquatic areas.

Zebra mussels initially migrated from the Black and Caspian seas to Europe via manmade canals. For almost 200 years, the mussels had resided in the fresh waters of western and central Europe without further spread. Zebra mussels and other exotic species apparently journeyed via cargo ship ballast water from Europe to the Great Lakes in the 1980s.

Cargo ships take in ballast water to redistribute weight when cargo is unloaded. The water is loaded in one port and expelled in another, depositing anything present in the water.

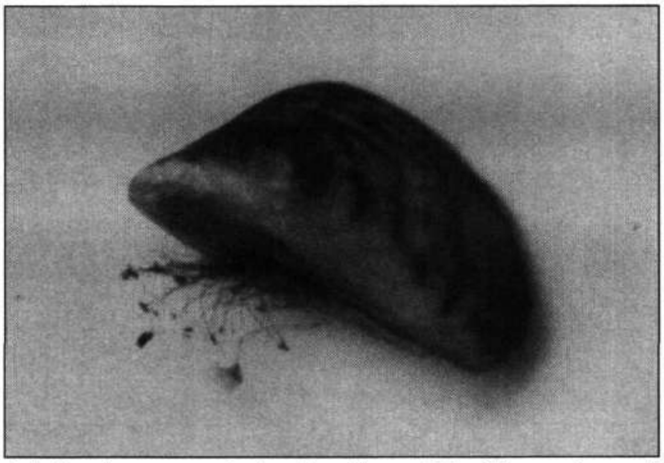
Reproductive Cycle Promotes Spread

One mature female zebra mussel can produce up to 40,000 eggs per season, so they can rapidly colonize a water body. The spawning season apparently lasts as long as water temperatures exceed 54 degrees F (12 degrees C), although this is still under study and observation in the waters of our region.

Zebra mussel eggs hatch within a few days. The young are microscopic larvae, called veligers, and can be carried great distances in water currents. Veligers float in the water an average of eight to 14 days, and up to 30 days, during which time they must attach to a firm surface or they will die.

Variety of shell color and patterns seen in zebra mussels in North America. Credit: Ellen Marsden

Those that hatch and survive, transform within three weeks into double-shelled mussels with light and dark banding. They mature in a year. The veligers and adult mussels produce thread-like filaments to attach themselves to any hard surface.



Adult zebra mussel showing thread-like filaments used for attaching to hard surfaces. Credit: Ohio Sea Grant.

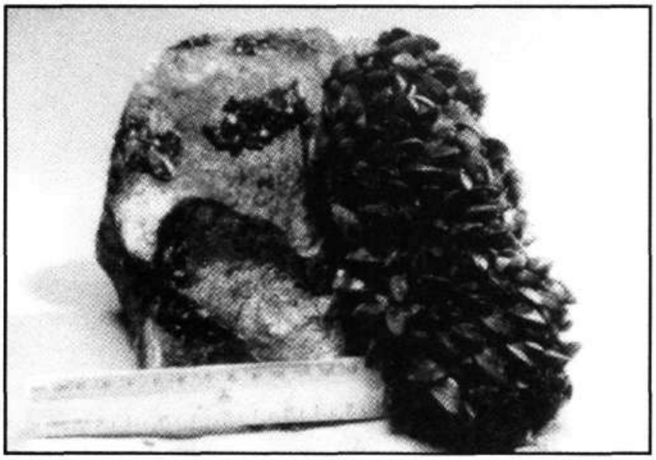
Though the majority of the mussels are thumbnail size, zebra mussels can reach 2 inches long when fully grown. The mussels live an average of 3.5 years but can live as long as five years.

Biological and Ecological Concerns

The zebra mussel's feeding habit is of great concern because of the damage it may cause to the Great Lakes' food chain. Each adult mussel is capable of filtering about 1 liter of water per day. Nearly all particulate matter, including plankton, is strained from the water. The zebra mussels eat mostly algae, selecting primarily those in the 15 to 40 micrometer size range for consumption.

Instead of passing the uneaten plankton back into the water, the mussels bind it with mucous into a pellet called pseudofeces. These pseudofeces are ejected from the mussel's siphons and accumulate among the shells in the colonies. Thus, a considerable quantity of plankton is removed from the water and becomes unavailable to the microscopic crustaceans that feed larval and juvenile fishes and unavailable to the plankton-feeding forage fish that support some of the Great Lakes' sport and commercial fisheries.

There are other concerns regarding reefs and rocky habitats. Most rocky areas in Lake Erie appear to be almost completely covered with mussels. The zebra mussels attach to a hard surface and then to one another, sometimes forming layers several inches thick. The accumulation of pseudofeces in these beds creates a foul environment. As the waste particles decompose, oxygen is used up and the pH becomes very acidic. Research is occurring to determine if these anaerobic, acidic conditions will be detrimental to the hatching success of reef-spawning fish species such as walleye, white bass and smallmouth bass.



Zebra mussel cluster on rock. Credit: Ontario Ministry of Natural Resources.

Impact on Industry and Recreation

In addition to Great Lakes ecosystem damage, zebra mussels can also harm industry and recreation. Mussels encrust and clog municipal and industrial water intake pipes, reducing pumping capabilities. When zebra mussels die and decompose, they can cause bad tastes and odors in drinking water. Though a zebra mussel may die, its shell stays firmly attached to whatever it adhered to when it was alive. Other zebra mussels can attach themselves to the hard shells and create layers of zebra mussels several inches thick. Zebra mussels have the potential of ruining Great Lakes recreational activities such as sport fishing, shipwreck diving and beach walking.

Shipwrecks can become colonized by mussels. Scuba divers have already reported wrecks virtually unrecognizable because of mussels. Beaches become less attractive when the sharp zebra mussel shells wash ashore.

Zebra mussels can accumulate in water intakes of both inboard and outboard motors, grow inside motors and cause engines to overheat. Navigational buoys can become encrusted with zebra mussels and sink out of sight from the weight.

Zebra Mussel Management

Methods of zebra mussel control such as chemical treatment (including chlorination), heat, electrical shock and sonic vibrations are being researched. Though some treatments are effective in managing the mussels in enclosed areas, researchers have yet to find a way to manage the mussels on a lake-wide basis.

Slow the Spread of Zebra Mussels

Microscopic larvae (veligers) can be unknowingly transported in bilges, engine cooling systems, minnow buckets, live wells and anywhere else that water is trapped. Zebra mussels will likely spread from the Great Lakes to inland waters. Here are some precautions you should take to avoid being a zebra mussel carrier:

-Always inspect your boat and trailer carefully before transporting them.

-Flush clean water (from hose spigot, etc., not lake water) through the cooling system of your motor to rinse out any veligers before relocating.

-Drain all bilge water, live wells, bait buckets and engine compartments. Make sure water is not trapped in your trailer.

-In their earlier stages, attached zebra mussels may not be easily seen. Pass your hand across the boat's bottom — if it feels grainy or grimy, it's probably covered with mussels. Don't take a chance — clean them off by scraping or blasting.

-Full-grown zebra mussels can be easily seen clinging tightly to surfaces. Carefully scrape the hull or trailer or use a high pressure spray (250 psi) to dislodge them. An alternative is to leave the boat out of the water for at least 14 days. The zebra mussels will die and can be scraped off.

-Dispose of the mussels in a garbage container. Don't leave them on the shore where they can be swept back into the lake or rot and foul the area.

-Before you leave the boat launch site, remove any plant debris from the trailer — small mussels may be entangled in it.

-Avoid transporting bait fish or water from one lake to another — you could be transporting microscopic veligers.

-Certain polymer waxes discourage zebra mussels from attaching. You will still need to check your hull periodically because the mussels cling to drain holes and speedometer brackets.

Some boat hull paints have pesticidal qualities. Before applying a chemical to your boat, be sure it is a legal and environmentally sound application by checking with the Pesticide and Plant Pest Management Division of the Michigan Department of Agriculture which regulates pesticide use. Do not use copper paints on aluminum hulls — galvanic corrosion would result.

Leeches

Of the 50 species of leeches found in Michigan, only four attach themselves to humans. Therefore, it is vital to determine if the leeches you see are truly causing a problem and can be considered pests. To some, a pest leech is known as a "bloodsucker."

Leeches dwell in accumulations of twigs and leaves at the lake bottom. A desirable leech management strategy is to allow large bluegills and bass to eat them — leeches are their preferred prey. Reducing the amount of organic debris and preventing or controlling beds of dense vegetation will also help reduce leech populations. Remember that a combination of shallowness and over fertility may be the cause of the excessive vegetation and organic debris buildup.

Insect Pests Associated with Aquatic Areas

Insects are invertebrates that have an exoskeleton — an external supportive covering for the other body parts. There are many aquatic insects, but only two of the most common and annoying insect pests requiring control are mentioned here.

Black Flies

Black flies are true flies (Diptera), related to mosquitoes, gnats, midges and crane flies. The larvae of black flies live in clean, fast-flowing streams and rivers. Adult black flies often emerge in great numbers from these water bodies in the spring and continue through the summer, though black fly adults are usually most abundant in May and June. Female black flies bite and suck blood, so they are important pests in resort and tourist areas and on farms.

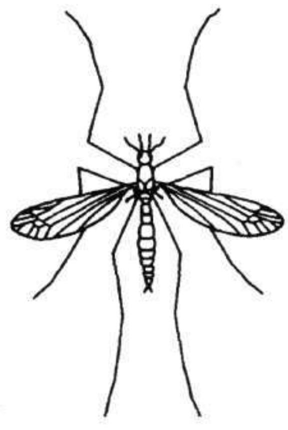
Black flies may become so numerous that people wish to control them. One way is to treat the larval stage by applying an insecticide derived from a common soil bacterium in the water where larvae are found (permission must be obtained before this treatment can be executed, inquire with the MDNR). This insecticide is available commercially in liquid form. When used according to the label directions, it is highly specific — it affects only black fly larvae and a small percentage of the midge larvae in streams and rivers, and it does not harm other aquatic organisms.

This bacterium-derived insecticide produces a crystalline, proteinaceous toxin that black fly larvae must ingest to be effective. After ingestion, the toxin is activated by the presence of a high gut pH and certain enzymes. The toxin binds to specific sites on the gut walls of the larvae. The gut walls disintegrate and the larvae die.

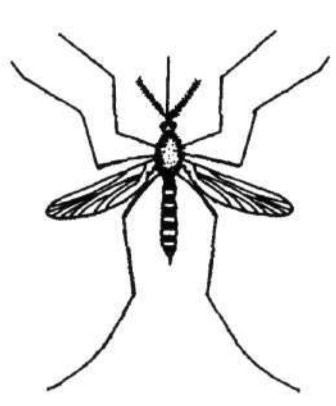
Anyone who wishes to control black flies shou seek expert help from an MSU Extension aquati insect specialist to learn about the biology an seasonality of black flies and the best management techniques available.

Mosquitoes

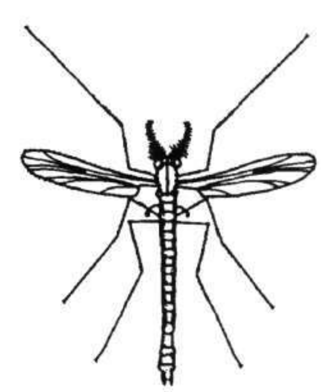
Mosquitoes have four distinct stages of development: egg, larva, pupa and adult. Eggs must be in water to hatch. They can be deposited either directly on water or in locations subject to periodic flooding. The larvae and pupae are aquatic, but the adults are active, free-flying



CRANE FLIES
Proboscis usually not present. Scales never present on wing veins or edge. Legs very long.

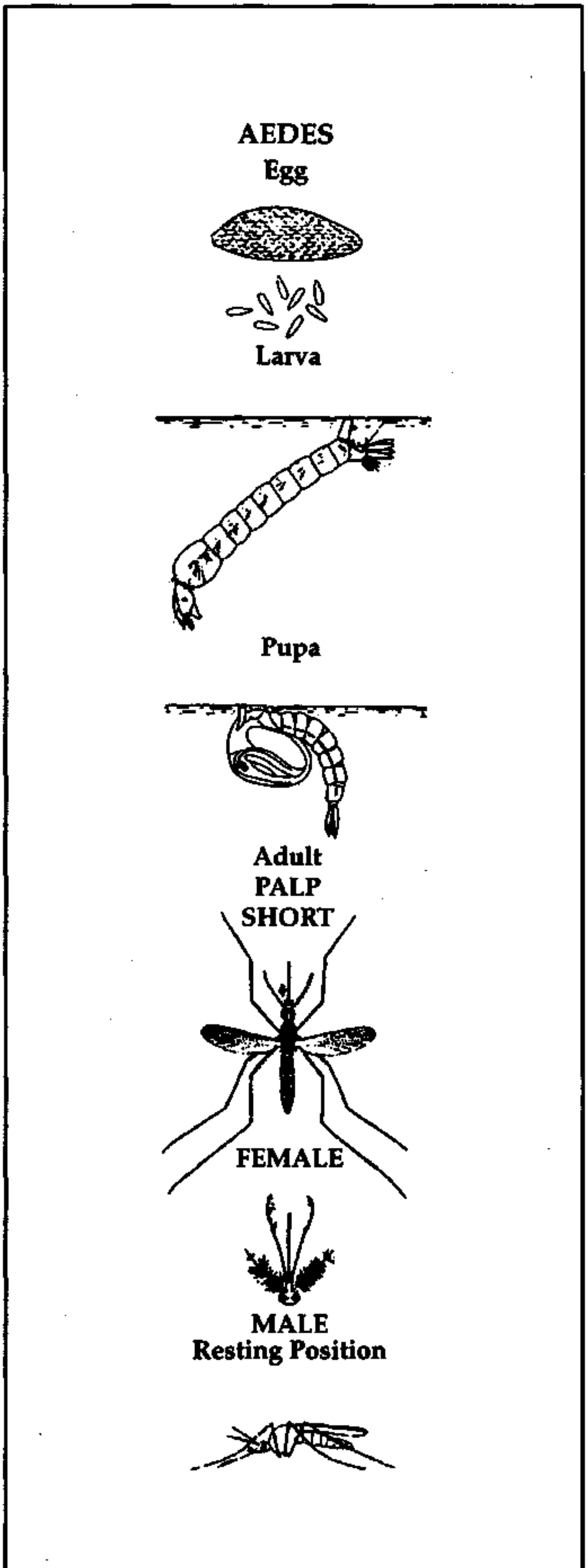


MOSQUITOES
Proboscis (elongated mouthparts) on front of head. Scales present on wing veins and wing edge. Rest with body held away from substrate



MIDGES
Proboscis never present. Scales never present on wing veins or edge. Rest with body nearly contacting substrate.

Crane flies and midges are insects commonly confused with mosquitoes.



Four life stages of a common mosquito species in Michigan: egg, larva, pupa and adult.

insects. Several species of mosquitoes are found in Michigan.

If you desire to manage mosquitoes commercially and make pesticide applications for this purpose, you must become a certified pesticide applicator in category 7F, mosquito control. Your certification as an aquatic pesticide applicator does not allow you to recommend or apply treatments for mosquito management.

Nonchemical approaches to mosquito reduction may include:

- Eliminating sources of stagnant water from the yard (bird baths, tires, pet dishes, buckets, etc).
- Increasing water movement in permanent water features.
- Reducing shallow water where feasible.
- Reducing the density of aquatic plants.

Chapter 11 – Invertebrates Review Questions

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

1. Which invertebrate is the host for the pest that causes swimmer's itch?
   a. Leeches.
   b. Mussels.
   c. Snails.
   d. Water fleas.

2. A molluscicide labelled for use in an aquatic setting is safe for all organisms in that aquatic environment. True or False?

3. Which statement about leeches is incorrect?
   a. Leeches dwell in twig and leafe accumulations on lake bottoms.
   b. Reducing amounts of organic debris and preventing/controlling beds of dense vegetation can help reduce leech populations.
   c. All 50 species of leeches could be harmful to humans at some time.
   d. Leeches are the preferred prey of bluegills and bass.

4. Which statement about the zebra mussel is incorrect?
   a. A mature female can produce up to 40,000 eggs in one season.
   b. The young, microscopic larvae are called veligers.
   c. During their 8 to 14 days as larvae, they must attach to a firm surface.
   d. The zebra mussel has been relatively harmless since arriving in the Great Lakes in the mid-1980s.

5. What type of organism does the zebra mussel filter from the water but not eat or pass back into the water, thus making this organism unavailable to crustaceans and fish?

6. Name four experimental treatments for zebra mussel management.
   1.
   2.
   3.
   4.

7. Zebra mussels can potentially be spread from the Great Lakes into inland waters unknowingly in bilges, engine cooling systems, live wells, and in any trapped water. True or False?

8. Instead of a spinal column, what do insects have that classify them as invertebrates?

CHAPTER 12

VERTEBRATES

Most wild mammals, birds, reptiles and amphibians are beneficial and desirable around water bodies. Some, however, may conflict with the interests of riparians (those who live adjacent to water bodies) or aquaculture businesses, and you may be asked for advice on how to manage these animals.

Just as regulations and permits are required for your pesticide application procedures, other regulations govern handling wildlife. If you're asked a nuisance wildlife management question, you should first refer the person to an agency experienced in fisheries and wildlife issues or suggest reliable resources for finding the answer.

In the past, the U.S. Fish and Wildlife Service responded to wildlife nuisance calls, but the overwhelming number of requests has made it impossible for the limited number of field staff members to service such requests. County animal control divisions should be the first agency contacted. Depending on the county, these offices may loan or rent live traps for persons to use to trap and relocate living animals. A few county offices may pick up the trapped nuisance animal and relocate or euthanize it (destroy it in a humane manner).

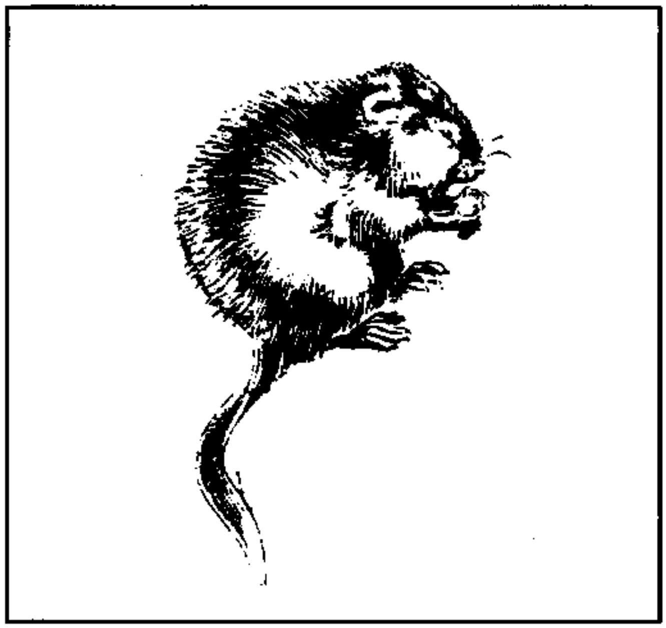
In urban areas, private businesses provide various types of animal management services. The local county animal control centers may refer you to these businesses. There are several excellent written resources you could suggest, also. The appendix in the back of this manual lists several of these references. The following discussion will give you some tips that the landowner can try before seeking additional help.

If you need help with an injured or sick animal or one that may be suffering from pesticide poisoning, you can seek assistance from the National Wildlife Rehabilitators Association (NWRA). NWRA is an organization of dedicated, knowledgeable people who care for thousands of injured, orphaned, poisoned or diseased wild animals each year. Members of the NWRA meet minimum standards and go through an accreditation program in wildlife rehabilitation. The central office for NWRA is based in Minnesota. By calling the NWRA office — (612) 437-9194 — you can get the name and number of a member close to your location who may assist you. The International Wildlife Rehabilitation Council (IWRC) may also be able to provide assistance with an injured or sick animal. The IWRC's telephone hotline is operated daily — (707) 864-1762.

When attempting to manage nuisance animals or alter their behavior, the first thing to recognize is that animal damage controls may not be 100 percent effective or permanent. The suggestions listed here should help reduce the damage but may need to be repeated.

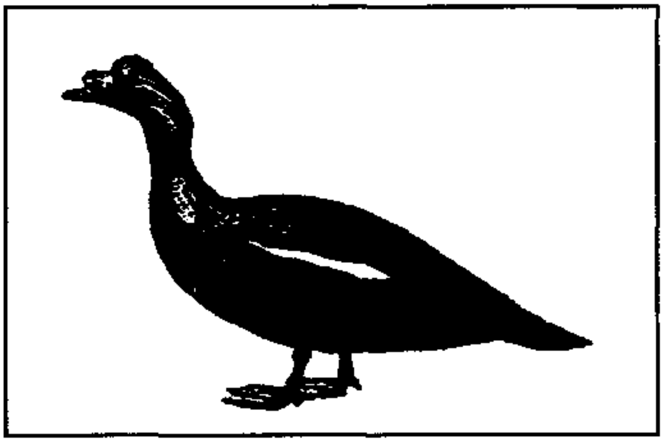
Muskrats and Woodchucks

Muskrats and woodchucks dig burrows that can cause pond bank cave-ins and may weaken dams or result in leaks. They prefer to dig in steep banks. Muskrats burrow from beneath the pond surface, while woodchucks typically tunnel into the downstream side of dams.



Keeping earthen dams mowed reduces cover that woodchucks and muskrats like. Removing cattails, arrowhead, and other emergent plants deprives muskrats of food and cover. Armoring the shore with rock and other hard materials will discourage burrowing.

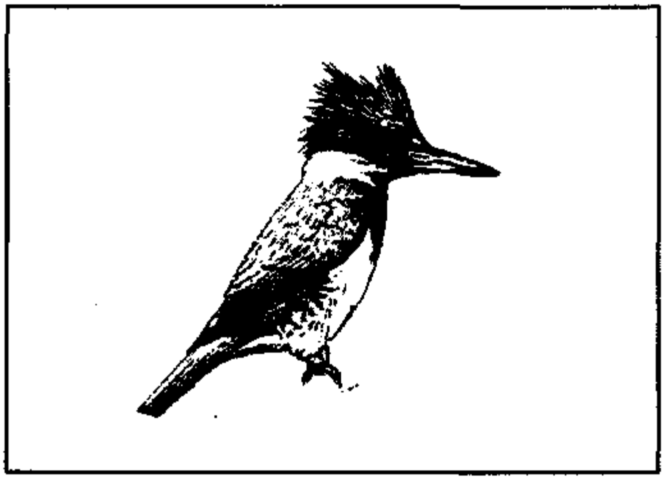
Controlling a muskrat population is usually feasible only if the water body is far from other muskrat habitat. If it's near other waterways or wetlands, muskrats will continually move in. In such cases, it may be better to control the damage by reinforcing the embankments rather than trying to control the muskrats.



Muskovy duck

Birds

Several kinds of fish-eating birds may reduce fish populations in ponds. Kingfishers, herons, mergansers and domestic muskovy ducks are notable predators. All of these can be scared away by noise-making devices. Floppy scarecrows, large rubber snakes, and owl or hawk decoys can also be used to scare birds away. These decoys must be positioned imaginatively and moved often.



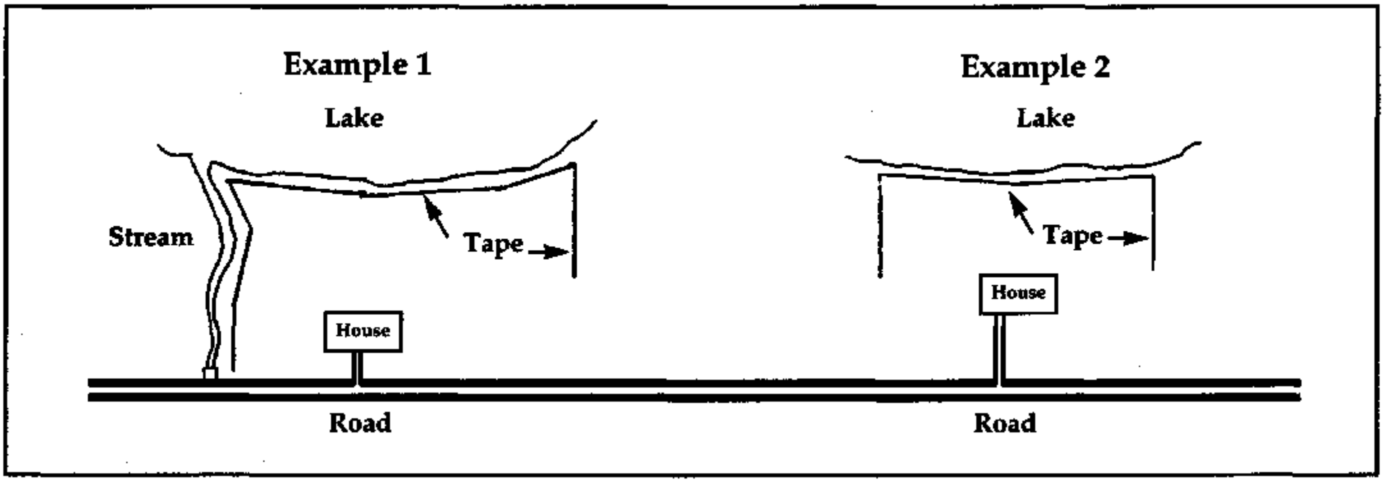
Kingfisher

Discourage herons by deepening pond edges to form steep underwater slopes. Three feet of horizontal distance per foot of drop is the maximum slope recommended for safety.

Discourage kingfishers by removing all perches such as posts and dead tree limbs close to the pond. If muskovy ducks are kept at the pond, confine them to a small part of it.

Geese, gulls and some duck species can become nuisances by feeding on lawns and depositing significant amounts of feces. String or bird repellent tape can be strung to discourage the geese and ducks from entering the yard. String must be strong. Bird repellent tape is red and silver aluminum foil coated with mylar. Its physical presence, the flashing colors, the noise it makes when the wind blows, its strength and its ease of application make it an ideal tool for managing bird damage in certain situations.

In yards, stretch the string or tape along the waterfront of the yard and up both sides, 6 inches above the ground for ducks and 15 inches above the ground for geese. Use whatever convenient supports the yard provides: trees, shrubs, posts, etc.



Properly placing bird repellent tape can help keep ducks and geese from becoming a nuisance.

If using the mylar bird repellant tape, give each section of tape a few twists. Put the barrier up as soon as possible after the ice melts. Immediately harass (bang on pots, shout and wave your arms while running toward them) any ducks or geese that cross the tape or string. Inspect and repair the barrier daily.

Large, tethered helium-filled balloons have proven effective in repelling blackbirds, ducks, geese, gulls and sandhill cranes from small agricultural fields and may be worth trying on a waterfront property to keep nuisance birds off of docks, swimming platforms and pontoon boats. The balloons must be moved periodically so that the birds do not become familiar with them and lose their fear.

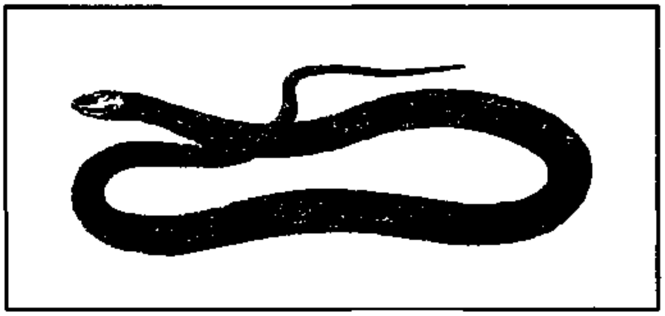
Canada geese may be undesirable when they deposit excessive amounts of feces on lawns or uproot grass plants.

Ducks, geese and water birds can be carriers of diseases other than swimmer's itch. They can also significantly increase fecal coliform bacteria counts and add nutrients to the lake.

Harassing these birds excessively may be a violation of the Migratory Bird Act. Contact a regional MDNR wildlife biologist or the U.S. Fish and Wildlife Service to learn more about this law, your actions and your responsibility. Shooting these birds without proper licensing or shooting out of season can lead to criminal prosecution.

Snakes

Snakes are beneficial animals that are extremely unlikely to cause harm to humans. In fact, some are protected. Some people, however, consider the mere presence of snakes a nuisance. Fish-eating water snakes may take up residence near a pond, especially when a stream is nearby. Water snakes usually pose problems only for trout and minnows.

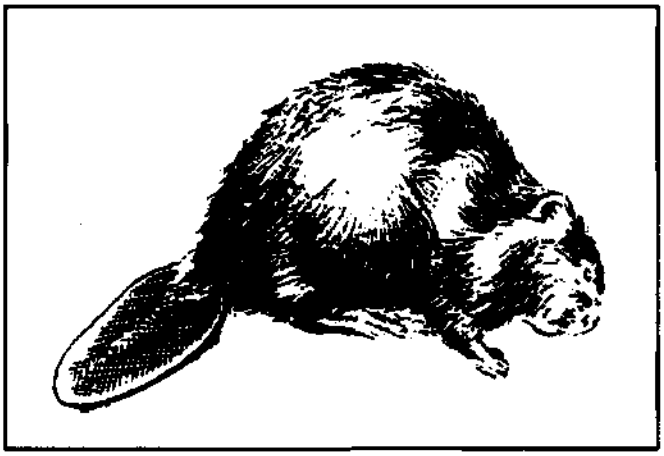


Mowing pond bank vegetation and removing logs, tree roots, branches and large stones from the shoreline reduces the habitat for water snakes. The mowing, however, may reduce the advantage of having a vegetational buffer strip to filter nutrients and silt out of runoff water. Leaving an unmowed buffer behind the mowed section is recommended to optimize the filtering capacity of the vegetation strip.

Beaver

The beaver is well adapted for aquatic environments and may be found anywhere there is a year-round source of water. Most damage caused by beaver is a result of dam building or tree cutting.

A single tree or shrub can be protected from beaver damage by encircling it with securely fastened wire mesh. Stucco wire or other stiff products are preferred; common chicken wire, unless well staked, is usually too light to do the job. The wire must be at least 30 inches high and larger than 2-inch mesh wire.



For detailed information on keeping culverts free of beaver dams and managing pond or stream levels with existing beavers and beaver dams, obtain the MDNR publication "Nuisance Beaver Control" from a district DNR office.

Chapter 12 – Vertebrate Review Questions

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

1. What can be done to reduce muskrat and woodchuck populations?
   a. Plant cattails, which are muskrat deterrents.
   b. Remove rocks from the shore to reduce their hiding places.
   c. Steepen the banks of the river or pond.
   d. Keep earthen dams mowed to reduce cover.

2. In a muskrat-infested area, it is better to control the muskrats than to try to prevent damage they cause. True or False?

3. What should be done to a pond to discourage herons?

4. Which of the following is not a suitable method for removing or discouraging birds?
   a. Shooting foreign birds.
   b. Noise-making devices.
   c. Stretching bird repellent tape along the waterfront.
   d. Helium balloons.

5. Several species of water snakes are harmful to humans and fish. True or False?

6. ______________________________ can be fastened around a tree or shrub to protect it from beaver damage.

7. If you need help with an injured or sick animal or one that may be suffering from pesticide poisoning, what two organizations could you call?

8. Can you expect animal damage controls to be 100 percent effective or permanent when attempting to manage nuisance animals or alter their behavior?

   Yes or No?

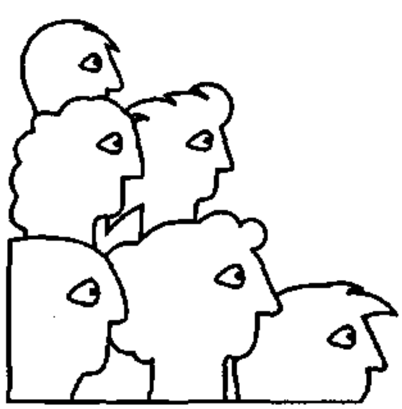
9. Ducks, geese and water birds can be carriers of other diseases besides swimmer's itch. True or False?

10. What is a disadvantage of mowing pond bank vegetation to reduce water snake habitat?

CHAPTER 13

Public Relations and Risk Communication for Aquatic Pest Managers

Aquatic pesticide applicators do their work in sensitive areas — sensitive to the environment and sensitive to public perception. The objective of their work is to change the environment. This may at first appear to be detrimental. However, aquatic plant management programs should be based on scientific research and years of experience, and they are designed to protect and improve the environment. If these programs are carried out correctly, the results are long-term benefits to water resources and their users. Misapplication or poor programs can result in fish kills or damage to nontarget plant communities or crops. The aquatic pesticide applicator must be aware of the potential impacts of misapplication and how to avoid them.



Often the general public does not fully understand the goals of aquatic pest management programs and their techniques. Because aquatic pesticides are placed directly in water where the public can come in contact with them through recreational activities and domestic water use, and because of the keen public interest in the environment, mistrust of aquatic pest management programs often develops. Therefore, aquatic pesticide applicators must be able to address environmental concerns while conducting their daily operations. Knowledgeable applicators are much appreciated by concerned individuals and also greatly benefit the entire aquatic plant management profession. Review the information in the chapter on herbicide technology and environmental fate in this manual so you can communicate these principles effectively.

This chapter discusses some of the requirements that a chemical must satisfy before becoming a registered pesticide and ways to better understand and work more effectively with the public. Identifying your audience, being technically knowledgeable and practicing ways to share this information will improve your risk communication skills.

Data Requirements for Pesticide Registration

Because pest managers have direct contact with the public every day, they have an excellent opportunity to inform and educate people. When an applicator offers a homeowner literature about the techniques and pesticide products he/she uses and answers questions relating to these practices, their use is less likely to become a problem or an issue for the homeowner. Providing pesticide product information and discussing how these products become registered helps people understand the risks and benefits of pesticide use.

Before an aquatic pesticide is labeled by the EPA, research requiring approximately 10 years to complete must be conducted. Data required for pesticide registration include, but are not limited to, the following:

1. Potential residue in potable water, fish, shellfish and irrigated crops.

2. Environmental fate of the compound — where it goes after application and what happens to it when it gets there. (Review the chapter "Herbicide Technology and Application Considerations" in this manual.)

3. How the compound breaks down and what the breakdown products are.

4. Whether the compound is absorbed through the skin or other acute routes of entry by test animals.

5. Short-term or acute toxicity of the compound to test animals.

6. Whether the compound causes birth defects, tumors or other abnormalities after long-term exposure.

7. The toxicity of the compound to aquatic organisms such as waterfowl, fish and invertebrates.

These data are rigorously reviewed by the manufacturer, the EPA and the MDA before a product is labeled for use in Michigan. An aquatic pesticide is not labeled until it is determined that it will perform its intended function without unreasonable adverse effects on the environment.

Being able to successfully communicate this pesticide registration process and other information to the public may turn fear of pesticides into understanding and acceptance of their use.

Differences in Perception

Differences in perception between applicators and those alarmed about the pesticide applicators' work are likely. Aquatic applicators can take steps to avoid negative reactions. These will be discussed later. First, let's look at how a confrontation develops so we can learn how to turn it into an informative and beneficial conversation.

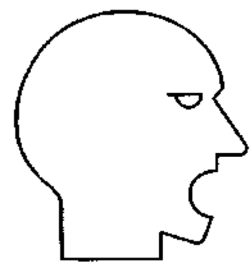
As a professional applicator, realize that you have considered your pest management practices, you understand the hazard associated with their use (for example, operating a harvester or using pesticides, which are hazardous substances) and you have voluntarily accepted the actual risk of using them — e.g., the chance of injury or damage from using a pesticide.

However, when members of the public experience a risk for the first time, an increased degree of risk or a new perception of risk e.g., exposure to pesticide in water, they respond with an emotional response evoked by everything about a pesticide except how likely it is to be harmful. An applicator needs to view public questioning as an opportunity to exchange information.

Risk communication is an interactive exchange of opinions and information. This exchange may be between individuals, the applicator and the client or the applicator and an outraged citizen, for example. Risk communication is necessary among groups, such as lake associations, institutions and/or agencies, including the Department of Natural Resources, the Michigan Department of Agriculture, the Environmental Protection Agency, universities and others.

How do people perceive risk? Any discussion about pesticides, their application, or pesticide residues has the potential to create serious concerns among consumers, possibly resulting in outrage. Looking at how people perceive risk helps to develop an understanding of why pesticides and their use produce such strong, potentially negative emotions.

Pesticides may be perceived as being risky because people feel they do not have control over their exposure to them, especially in an aquatic setting where chemicals can disperse over large areas, or possibly when the decision to apply a pesticide did not include their consent.



Outrage over pesticide use is heightened when people feel that someone else is benefitting while they, or the environment, are assuming the risk. Review Table 13-1 to see what qualities and perceptions cause something to appear more or less risky.

Less risky	More risky
Voluntary exposure	Involuntary exposure
Familiar	Unfamiliar
Controlled by self	Controlled by others
Fair	Unfair
Not fatal	Fatal
Natural	Artificial
Detectable	Undetectable
Old risk	New risk
Known to science	Unknown to science
Not in my backyard	In my backyard

Table 13-1. Characteristics that contribute to perception of risk.

To improve communication about benefits and risks:

Engage in early and sustained interaction with all stakeholders. Communicating with riparians and other interested persons before, during and after a pest management treatment will help build trust. Interaction includes one-on-one discussions, attending lake association meetings, using newsletters, providing product literature, posting and making follow-up visits to treated sites.

Listen. Communication is a two-way activity. Let all parties with an interest be heard. If you do not listen to people, you can not expect them to listen to you.

Communicating is a two-way activity.

Accept emotions as legitimate. Acknowledge the feelings of people; put yourself in their place as well as you can. People are generally more concerned about trust, fairness and compassion than LD_{50}s or risk assessment.

Avoid finger pointing, such as: "Aquatic herbicides are needed because all the homes on this lake have septic fields that leach into the water." No one likes to have a finger pointed at him/her as the root of a complex problem, especially when he/she may have no control in the matter.

Be cautious of using comparisons of different risks. A voluntary activity such as water skiing does not cause the same level of concern as involuntary exposure to pesticides in a body of water where someone recreates. Comparisons are not a good way to justify risks.

Be honest and state your credentials and limitations. Do not ask or expect to be trusted. Disclose information as soon as possible, use credible sources, and use simple, nontechnical language. Acknowledge uncertainties and limits to scientific knowledge. If you do not know an answer, say so. Get back to people later with answers or direct them to a resource that can address their concerns.

Maintaining Public Confidence

Reduce pesticide use to the lowest level possible. Pesticide applicators must practice integrated pest management to reduce the number of pesticide applications, maximize the effectiveness of each application and minimize pesticide impacts.

Seek to restore confidence in the ability of governmental agencies to protect the safety of commercial pesticide applications. Avoid publicly voicing any negative opinions about regulatory agencies. Instead, make positive suggestions about how regulatory agencies might improve.

Educate consumers about the steps taken to protect their safety. Notify waterfront residents before making applications and be sure all treated areas are visibly posted. Be sure all equipment is in proper working order and calibrated.

Listen to what the customer is asking and respond in a timely manner.

Communication is never a one-way process. It is essential to listen to what consumers are saying about changes they would like to have in the methods used to manage aquatic pests or in their willingness to accept a larger pest population.

Those who use aquatic pesticides must recognize that community members believe that their concerns about pesticides are legitimate. It is the public mindset that encourages community leaders and legislators to regulate commercial pesticide use. There will no doubt be increased regulations and restrictions imposed upon pesticide applicators. Applicators are expected to conduct themselves professionally and with safety consciousness.

Applicators can avoid potential criticisms by being considerate of public concerns, being knowledgeable and informative, and using common sense and extra care while handling and applying pesticides.

Professionalism

When you are in the aquatic pest management industry, you should:

- *Remember that part of what you are selling is your reputation.* Do not bid lower than you feel is truly reasonable to do the job properly. Let someone else cut corners — there is no surer way to run into problems.

- *Choose your employees carefully and train them with equal care.* There is a direct correlation between lack of experience and training of the crew and the number of problems that can be expected on the job. Some of the problems associated with an inexperienced or poorly trained crew may simply cost you money; others may cost you an enforcement record.

- *Make sure you and your employees know who the client is and what that client expects.* It may appear that it will cost you less not to train crew members, but it will cost you more in the long run if you lose a business opportunity because you didn't meet the standards of the contracting agent.

If you have field staff members working on aquatic pest management programs, you should:

- *Train new employees how to use materials and equipment safely and accurately.* This training can be a refresher course for experienced employees. Teach your employees in the pest management program to be sensitive to the concerns of the public. If your work is in resort or outdoor recreation areas, keep in mind that the public will view any visible maintenance impacts and water use restrictions as interfering with their enjoyment of the outdoors. Make sure you and your applicators are aware of local concerns and are alert to any conflicts that may develop as a result.

- *Establish policies for your employees that outline exactly what you expect of them when they are at an application site.* Make sure that you enforce those policies and that you have a system for dealing with any employees who do not conform to those policies. Make sure employees use PPE and follow pesticide label directions.

- *Keep in touch with state regulatory agencies:* the Michigan Department of Agriculture and the Michigan Department of Natural Resources. Make sure that you know the latest requirements for conducting your business. Ignorance of the law is no defense. Some sources of information are:

- Labels and Material Safety Data Sheets (MSDS).
- Michigan State University Extension.
- Field demonstrations.
- Chemical company staff members.
- Industry publications.
- Applicator training seminars.

- *Let your regulatory agency know where and when you are working.* Much of this is accomplished through the permit process. This helps agency staff members respond to inquiries and gives them the opportunity to come out to the site and see what is going on. It lets them become familiar with your operations and you with theirs. You benefit because the agency can help identify potential problems before they become serious.

The basic rule for safe pesticide applications is: "Follow the label and use common sense." Common sense dictates that you remember that you or the people who work for you are using potentially dangerous chemicals. Your objective should be to make sure they are used properly and carefully. Don't be your own worst enemy by tolerating carelessness in your operations.

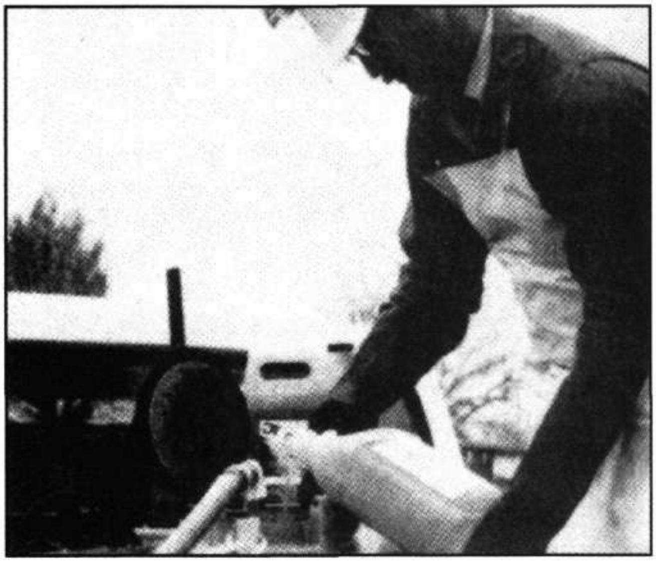
Safety Measures

Use of pesticides to control aquatic plants and other pests causes concern for many people. Typically, these concerns involve what products are being used and whether they are safe. Understand and be able to communicate the pesticide registration process, the pesticide's mode of action and the environmental fate of pesticides.

Most compounds do not make it through the registration screening process and are never marketed as pesticides. Those that do have undergone extensive review — a review that will continue throughout the product's life. Detailed Material Safety Data Sheets (MSDS) and concisely stated product labeling outline conditions of safe use established by extensive research and assist the applicator in performing operations safely.

Applicators on the job should:

1) Have available product information
   - Sample label.
   - MSDS.
   - Literature.
2) Respond to public inquiries:
   - Get name, address and phone number.
   - Do not spray without owner's permission and appropriate permits.
   - Distribute literature.
   - Resolve complaints in a timely manner.
3) Be professional
   - Maintain equipment.
   - Dress properly and appear neat.
   - Wear PPE when handling and applying pesticides.
   - Be polite.



Be professional and responsible: wear the appropriate safety equipment.

Often a waterfront property owner's questions about pesticide applications go unanswered or are not answered to his/her satisfaction. This generally results in a formal complaint and polarized viewpoints. Landowners feel the applicator is hiding something and the applicator may view their questions as a nuisance. A simple solution to this problem is to know the answer to the landowners' questions before they are asked. A quick, direct response to the public's concerns facilitates better communications and a more enjoyable working environment. Be prepared to respond to such commonly asked questions as these:

- What are herbicides and why are they used?
- Do aquatic herbicides affect fish and reptiles?
- Can we use the water for irrigating after it's been treated?
- What should we do if our dog swims in or drinks the treated water?
- What kinds of precautions are taken to make sure that pesticides don't get into groundwater supplies?
- Do herbicides and other pesticides pose any risk to me and my family?
- What happens if herbicides move out of the treated area?
- If my cattle drink treated pond water, will they be harmed?

Chapter 13 – Public Relations and Risk Communications Review Questions

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

1. List four or more types of data and information required for a pesticide to become registered with the EPA.

2. Who reviews the data collected for pesticide registration?
   a. Manufacturers.
   b. EPA.
   c. State governments.
   d. All of the above.

3. What is risk communication?

4. Why are pesticides perceived as risky, and how is that risk heightened?

5. What characteristics contribute to the public's perception of risk?
   a. Involuntary exposure.
   b. Unfair.
   c. Artificial.
   d. Undetectable.
   e. All of the above.

6. How can a pesticide applicator improve communication?

7. How can an applicator maintain public confidence?
   a. Use IPM practices.
   b. Educate consumers about steps taken to protect their safety.
   c. Build confidence in governmental agencies.
   d. All of the above.

8. Why is it important to train employees carefully?

9. Labels and Material Safety Data Sheets (MSDS), Michigan State University Extension, field demonstrations, chemical company staff members, industry publications and applicator training seminars are all sources of current pesticide safety information. True or False?

10. What should applicators on the job be able to communicate about the pesticide they are using when dealing with the public?

Answers to Review Questions

Introduction and Chapter 1: Laws and Regulations

1. False. FIFRA is the federal law regulating pesticides and their use.

2. C

3. False. The Michigan Pesticide Control Act is Public Act 171 of 1976.

4. True

5. True

6. D

7. C

8. F

9. True

10. Michigan Department of Natural Resources (MDNR)

Chapter 2: Pesticide Safety

1. An applicator should know what pesticides are and how they work, what is the best product for controlling the target pest, the appropriate timing of the pesticide application, what personal protective equipment is necessary, how to mix, load and apply pesticides, proper storage and handling of pesticides, and pesticide fate.

Much of this information can be found on the pesticide label.

2. D

3. Brand name, ingredient statement, chemical name, net contents, registration and establishment numbers, name and address of manufacturer, signal words, statement of practical treatment, directions for use, etc.

4. D

5. Caution, Warning, Danger, and Danger Poison. Danger Poison signal words will also be displayed with a skull and crossbones symbol.

6. The minimum amount of personal protective equipment that must be worn when using the pesticide.

7. C

8. - Using the product at a lower rate than on the label.
   - Mixing two or more pesticides together if it is not prohibited according to label directions.
   - Applying the pesticide at the label rate on a pest when the pest is not listed on the label but the site where the pest is located is on the label and the label does not specifically prohibit treating the pest.

9. Hazard = toxicity x exposure

10. Hazard is the risk of harmful effects caused by pesticides. Hazard depends on both the toxicity of the pesticide and the exposure you receive in a given situation.

11. By reading the pesticide label an applicator can determine the minimum PPE to wear. Additional protection may be beneficial.

12. Long pants, a long-sleeved shirt or coveralls, gloves, plus socks and footwear. These garments provide minimum protection for granular pesticides and pesticides labeled with the signal word "Caution."

13. D

14. 1. Secure the area — keep people at a safe distance.
    2. Put on safety equipment to protect yourself from exposure.
    3. If possible, stop the leak without endangering yourself or others. To stop a small spill on the ground, use adsorbent material and contain it with a dirt dike. Do not use water, it will only spread the spill.
    4. Notify the local fire department.

Chapter 3: Integrated Pest Management

1. False

2. D

3. Monitoring

4. - Location of the body of water, and water uses — e.g., irrigation, recreational uses.
   - History of the water uses and previous management practices.

- Desired goals, objectives, attitudes and expectations of the water users.
- Water quality, fertility, pH, clarity, temperature, hardness.
- Inflowing and outflowing water routes.
- Fish species present, their age, size and abundance and ecosystem roles.
- Diversity of birds and animals, including bottom-dwelling organisms.
- Aquatic vegetation, submerged, emergent, shoreline and wetland.
- Bottom characteristics such as depth, slope, sediment type and quantity.
- Appearance of water's edge, shoreline or banks.
- Surrounding development and activity (housing, agriculture, industry, etc.) that can influence aquatic environments.

5. False
6. E
7. B
8. Weeds
9. A
10. C
11. E

Chapter 4: Conditions for Aquatic Plant Growth

1. D
2. Photic zone
3. B
4. Soft
5. True
6. A
7. B
8. D
9. -Life cycle.

   -Geographic distribution of aquatic plants.

10. So life stages susceptible to your management technique can be predicted and identified. With this information, management treatments can be targeted to the point in the pest's life when it is most easily controlled.
11. B

Chapter 5: Aquatic Plant Identification and Management

1. D
2. Planktonic-type filamentous algae
3. Exotic
4. 1. Serve as food, habitat or shelter for other aquatic organisms.

   2. As stabilizing features for the substrate.

   3. Filter storm and runoff water.
5. A
6. Curly-leaf pondweed
7. Turions
8. True
9. Annuals, seed
10. B
11. True
12. American eelgrass
13. Duckweed
14. C

Chapter 6: Nonchemical Aquatic Vegetation Management Techniques

1. 1. Prevention of weed spread.

   2. Elimination of nutrient sources that support growth.

   3. Deepening or increasing the slope of shallow areas where plants can grow.
2. False
3. Eutrophication is the aging and deterioration of a lake's ecosystem, often influenced by the addition of nutrients which increases production of plants and algae.
4. Point sources
5. B
6. 1. Prevent runoff by planting vegetation along drainage areas.

   2. Avoid fertilizing turf near water by leaving a 20-foot buffer.

   3. Prevent livestock from entering the water.

   4. Practice conservation tillage to prevent erosion.

   5. Construct a settling pond to receive nutrients before the flow reaches the main body of water.

6. Avoid adding fertilizers to a body of water.
7. Check for hidden sources of nutrients such as septic fields and drainage tiles.
8. Plant deciduous trees far enough from water bodies so leaves will not fall into the water and accumulate.

7. C
8. True
9. C
10. C
11. F
12. Biological
13. A
14. Biomanipulation

Chapter 7: Herbicide Technology and Application Considerations

1. C
2. 1. Proper identification of the weed or weeds.
   2. Uses of the water to be treated.
   3. Timing of the treatment.
   4. Water characteristics including temperature, alkalinity, % saturation of dissolved oxygen.
   5. Method of application.
   6. Probability of re-treatment, potentially within the same year.
   7. Impact on nontarget plants and animals.
   8. Weather.
   9. Cost.
   10. Permission from appropriate agencies and property owners/managers to perform the treatment.
3. False
4. **Contact** herbicides act quickly and are generally lethal to all plant cells that they contact.

   Systemic herbicides are absorbed into the living portion of the plant and move within the plant (translocate).
5. E
6. Plant growth regulator (PGR).
7. B
8. B
9. C
10. Turbidity
11. 1. Degraded.
    2. Become inactive.
    3. Dissipated.

Chapter 8: Aquatic Herbicide Application Equipment and Techniques

1. Application technique
2. A
3. False
4. True
5. A
6. Ethylene vinyl acetate (EVA).

   Ethylene propylene dione monomer (EPDM).
7. Pump inlet port.
8. 0-150 gpm, 70 psi
9. A
10. True

Chapter 9: Calibration: Applying the Right Amount of Herbicide

Work through examples 12-15 found at the end of chapter 9.

Chapter 10: Fish Management

1. Piscicides
2. False
3. 1. Large predators are unavailable.
   2. Sunfish are able to hide from predators in dense stands of weeds.
4. E
5. True
6. 1. When products are handled and transported.
   2. Where products are stored.
   3. At treatment site.
7. E

8. - Volume of inflow to the treatment zone.
   - Tributaries.
   - Volume of outflow.
   - Temperature.
   - Turbidity.
   - Chemical and biochemical oxygen demand.
   - Species composition.
   - Profile of water velocities across a stream channel.
   - Dilution.
9. True
10. - Chemical concentration (calculate volume of area being treated to determine dose).
    - Contact time (determine flow rate in cubic feet per second).
    - Type of target fish.
    - Water temperature (colder water temperatures may reduce effectiveness of piscicides).
    - Water turbidity and pH.
    - Weather conditions.
11. C
12. a. 200 ft. x 80 ft. x 5 ft. = 1.8 acre feet

    43,560 cubic ft/acre foot water

    1.8 acre ft x .326 gal. piscicide/acre ft water/ppm x 3 ppm = 1.7 gal

    or 1.7 x 3,785 ml/gal = 6,435.5 ml

    b. First, Duration of treatment (ECT) x Pumping rate (GPM) =

    15 ECT x .25 GPM = 3.75 gallons of solution.

    Next, Total solution – Amount of piscicide =

    3.75 gallons – 1.7 gallons piscicide = 2.05 gallons of water to add to sprayer.

13. Step 1 7920 ft x 15 ft x 5 ft = 594,000 cubic feet

    Step 2 $\frac{594{,}000 \div 20 \text{ cfs}}{3{,}600 \text{ sec/hr}} = 8.25$ hours

    Step 3 Part 1 – 1.5 ml/cfs/min x 60 min/hr = 90 ml/hr

    Part 2 – 90 ml/hr x 20 cfs x 8.25 hours = 14,850 ml

    Convert ml to gallons 14,850 ml – 3,785 ml/gallon = 3.9 gal

    Step 4 3 drip sites taken from chart.

    $\frac{7{,}920 \text{ ft}}{3} = 2{,}640$ ft. between drip sites.

    Step 5 3.9 gallons ÷ 3 = 1.3 gallons piscicide /site

    Step 6 $\frac{1.3 \times 3{,}785 \text{ml/gal}}{1.5 \text{ml/cfs/min} \times 60 \text{ min/hr} \times 20 \text{cfs}} = 2.7$ hr/site

    Step 7 20 cfs x 1.5 ml/cfs/min = 30 ml/min

Chapter 11: Invertebrates

1. C
2. False
3. C
4. D
5. Plankton
6. Chemical treatment, heat, electrical shock, sonic vibrations.
7. True
8. Exoskeleton

Chapter 12: Vertebrates

1. D
2. False
3. Deepen edges to form steep underwater side slopes.
4. A
5. False
6. Wire mesh
7. National Wildlife Rehabilitators Association (NWRA)

   or

   International Wildlife Rehabilitation Council (IWRC).
8. No
9. True
10. Mowing may reduce the advantage of having a vegetational buffer strip to filter nutrients and silt out of runoff water.

Chapter 13: Public Relations and Risk Communication

1. 1. Potential residue in potable water, fish, shellfish and irrigated crops.
   2. Environmental fate of the compound, or where it goes after application and what happens to it when it gets there.
   3. How the compound breaks down and what the breakdown products are.
   4. Whether the compound is absorbed through the skin or other acute routes of entry by test animals.
   5. Short-term or acute toxicity of the compound to test animals.
   6. Whether the compound causes birth defects, tumors, or other abnormalities after long-term exposure.
   7. Toxicity of the compound to aquatic organisms such as waterfowl, fish and invertebrates.
2. D
3. Risk communication is an interactive exchange of opinions and information.
4. Pesticides may be perceived as being risky because people do not feel they have control over their exposure to them, or the decision to apply them did not include their consent.
5. E
6. Begin early and maintain interaction with all stakeholders; listen; accept emotions as legitimate; avoid finger pointing; be cautious of using comparisons of different risks; be honest and state your credentials and limitations.
7. D
8. There is a direct correlation between the lack of experience and training of the crew and the number of problems that can be expected on the job.
9. True
10. They should understand and be able to communicate the pesticide registration process, pesticide mode of action and environmental fate of pesticides to satisfy questions.

GLOSSARY

Abiotic: Not relating to living organisms.

Absorption: The uptake of a chemical into plants, animals, or minerals. Compare with adsorption.

Active ingredient: A component of a pesticide product which has pesticide activity. Active ingredients are normally mixed with inert or inactive ingredients in the formulation process.

Acute exposure: Exposure to a single dose of pesticide.

Acute toxicity: A measure of the capacity of a pesticide to cause injury as a result of a single exposure.

Additive: Same as adjuvant.

Adherence: Sticking to a surface.

Adjuvant: A chemical added to a pesticide formulation to increase its effectiveness or safety.

Adsorption: The binding of a chemical to surfaces of mineral or soil particles. Compare with absorption.

Adulterated: (1) A pesticide whose strength or purity falls below that specified on the label. (2) A food, feed, or product that contains illegal pesticide residues.

Aerobe: An organism that requires oxygen for growth.

Agitation: The process of stirring or mixing in a sprayer.

Algae: A group of photosynthetic aquatic organisms containing chlorophyll, which may occur as simple cells or as long strands of cells.

Allelopathy: The production of growth inhibitors by one plant which retard the development of another plant.

Anaerobe: An organism which does not require oxygen for its growth.

Annuals: Plants that complete their life cycle within one year.

Antagonism: The loss of activity of a chemical when exposed to another chemical.

Antibiotic: Chemical compounds produced by microorganisms which are toxic to other microorganisms.

Antidote: (1) A chemical applied to prevent the phytotoxic effect of a specific herbicide on desirable plants. (2) A practical treatment for poisoning, including first aid.

Anti-siphoning device: An attachment to the filling hose designed to prevent backward flow into the water source.

Aquatic plants: Plants which grow on, in, or underwater.

Aqueous: Indicating the presence of water in a solution or environment.

Attractants: Substances that lure insects to traps or to poison-bait stations.

Avicide: A chemical used to control birds.

Bacteria: One-celled microorganisms able to grow independently without the presence of light. The cells may be spherical, spiral, or rod shaped.

Band application: Placement of a pesticide in a narrow area either over or along the crop row.

Beneficial insects: Those insects which are useful to people, e.g. predators and parasites of pest species, bees and other pollinators.

Bioaccumulation: The buildup of pesticides in the bodies of animals (including humans), particularly in fat tissue.

Biocide: A chemical able to kill microbial organisms.

Biological control: Control by predators and parasites, either naturally occurring or introduced.

Biological degradation: The breakdown of a pesticide due to the activities of living organisms, especially bacteria and fungi.

Biology: The science that deals with the structure, function, development, evolution, and ecology of living organisms.

Biotic: Relating to living organisms.

Biotype: Usually refers to a subdivision of a race.

Brand name: The specific, registered name given by a manufacturer to a pesticide product; same as trade name or proprietary name.

Broadcast application: The uniform application of a pesticide to an entire field or area.

Broad-spectrum pesticide: A pesticide that is effective against a wide range of pests or species.

Calibration: Measurement of the delivery rate and distribution of application equipment.

Carbamate: A synthetic organic pesticide containing carbon, hydrogen, nitrogen, and sulfur.

Carcinogen: A substance which has the ability to cause cancer.

Carrier: A liquid or solid material added to a pesticide active ingredient or formulated product to facilitate its field application.

Caution: Signal word associated with pesticide products classified as either slightly toxic or relatively nontoxic.

Cell: The basic structural unit of all living organisms. An organism may be composed of a single cell (e.g. bacteria) or many cells working together (all "higher" organisms, including humans).

Chemical degradation: The breakdown of a pesticide by oxidation, reduction, hydrolysis or other chemical means.

Chemical name: The scientific name of an active ingredient which complies with accepted guidelines established by chemists.

Chemigation: The application of an agricultural chemical by injecting it into irrigation water.

Chlorophyll: The green photosynthetic substance in plants which allows them to capture solar energy.

Cholinesterase: An enzyme found in animals that helps control the activity of nerve impulses.

Chronic exposure: Exposure to repeated doses of a pesticide over a period of time.

Chronic toxicity: A measure of the capacity of a pesticide to cause injury as a result of repeated exposures over a period of time.

Closed mixing system: Systems in which liquid pesticide concentrates are transferred from their original containers to mix or spray tanks through a closed series of hoses, pipes, etc.; they are designed to prevent or reduce exposure to the concentrates.

Coliform: A specific group of Bacillus bacteria associated with human or animal excreta.

Common name: (1) The standard, commonly-used name of a pesticide active ingredient established by appropriate professional societies. (2) A commonly used name of a particular species. Unlike scientific names, there may be a number of common names for the same species.

Compatibility agents: Chemicals that enhance the effective mixing of two or more pesticide products.

Concentration: The amount of active ingredient or herbicide equivalent in a quantity of diluent expressed as percent, lb/gal, kg/l, etc.

Cross contamination: When one pesticide gets into or mixes with another pesticide accidently; usually occurs in a pesticide container or in a poorly cleaned sprayer.

Cultural control: Control by changing management practices to reduce pest numbers without the use of pesticides.

Danger: Signal word associated with pesticide products that may cause skin and eye irritation more severe than suggested by the acute toxicity (LD_{50}) of the product.

Days to harvest: The minimum number of days allowed by law between the final application of a particular pesticide and the harvest date.

Deflocculating agent: A material added to a suspension to prevent settling.

Degradation: The breakdown of a pesticide into a simpler compound which is usually, but not always, nontoxic; degradation may be either chemical, physical, or biological or any combination of the three.

Deposit: The amount of a pesticide on a treated surface immediately following an application.

Dermal: Of the skin; through or by the skin.

Dermal Toxicity: Ability of a chemical to cause injury when absorbed through the skin.

Diatoms: Algae that have structured cell walls containing silica.

Diluent: Any liquid or solid material used to dilute or carry an active ingredient.

Dilute: To make thinner by adding water, another liquid or a solid.

Directed-spray application: A herbicide is directed specifically at target weeds in an effort to minimize contact with the crop.

Dispersing agent: A material that reduces the attraction between particles.

Dormant: State in which growth stops temporarily. May refer to plants, plant parts, microorganisms, and certain animals.

Dose, dosage: Quantity of a pesticide applied.

Drift: (1) The movement of pesticides through the air to nontarget areas either as solid or liquid particles or as vapors. (2) (Legal definition) The drifting or movement of pesticide by air currents or diffusion onto property beyond the boundaries of the target area to be treated with pesticide, other than by pesticide overspray.

Dust: A finely-ground, dry pesticide formulation in which the active ingredient is combined with an inert carrier such as talc, clay, powdered nut hulls, or volcanic ash; dusts are applied in the dry form.

Ecology: The science which studies the interrelationships of living organisms and their environment.

Economic damage: The amount of injury which will justify the cost of applied control measures.

Economic injury level: The population density at which a pest causes a reduction in the value of the crop that is greater than the cost of control.

Economic threshold or action threshold: The population density at which management measures should be instituted to prevent an increasing pest population from reaching the economic injury level.

Emulsifiable concentrate (EC or E): A pesticide formulation produced by mixing the active ingredient and an emulsifying agent in an organic solvent.

Emulsifier: A substance which facilitates the formation and maintenance of an emulsion.

Encapsulated pesticide: A pesticide formulation in which the active ingredient is encased in extremely small capsules made of inert synthetic polymers. The pesticide is released gradually over a period of time.

Endangered species: A group of organisms on the brink of extinction.

Entomology: The science that deals with the study of insects.

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

Enzymes: Proteins that increase the rate of specific chemical reactions.

EPA: The Environmental Protection Agency.

Epidemic: A temporary widespread outbreak of a disease.

Epinasty: That state in which more rapid growth on one side of a plant organ or part (especially leaf) causes it to bend or curl downward.

Eradication: The complete elimination of a pest from a site, area or a geographic region.

Erosion: Movement of soil and associated materials, principally by water and wind.

Exposure: To come in contact with a pesticide.

FDA: Food and Drug Administration.

FIFRA: The Federal Insecticide, Fungicide and Rodenticide Act: federal law dealing with pesticide regulations and use.

Filamentous algae: Algae that occur as long strands of cells.

Filamentous fungi: Fungi with an end-to-end arrangement of cells to form colorless branch filaments.

Flowable (F or L): A pesticide formulation in which the active ingredient is impregnated on a diluent such as clay which is then finely ground and suspended in a small amount of liquid; the resulting "paste" or "cream-like" formulation is added to water in the spray tank and forms a suspension.

Foaming agent: A material designed to reduce drift, which causes a pesticide mixture to form a thick foam.

Foliar application: Application of a pesticide to the aerial portions of either a crop or weed.

Food chain: A group of plants, animals, or microorganisms linked together as sources and consumers of food.

Formulation: The pesticide product as purchased, usually consisting of a mixture of active and inert ingredients.

Fumigants: Pesticides or mixtures of pesticides which produce vapors that are toxic when absorbed or inhaled.

Fumigation: The application of a fumigant.

Fungi: A group of lower parasitic plants lacking chlorophyll. Fungi are generally colorless, but may appear with a variety of colors (black, brown, green, pink, etc.) due to the color of the spores.

Fungicide: A chemical used to control fungi.

Fungus: A largely undifferentiated, usually microscopic organism lacking chlorophyll and conductive tissues and living either as a saprophyte or parasite. The vegetative body of a fungus is normally composed of hyphae, and reproduction is by sexual or asexual spores.

GPA: Gallons per acre.

GPM: Gallons per minute

Granules (G): A dry pesticide formulation made by applying a liquid formulation of the active ingredient to particles of clay or another porous material. Granules are applied in the dry form and have a particle size substantially larger than dusts.

Herbicide: A chemical used to kill or inhibit plant growth.

Host: An organism such as a plant or animal that is invaded by a parasite and serves as its food source.

Hydrolysis: Decomposition of a chemical compound by reaction with water.

Immune: Not susceptible to a disease or poison.

Impermeable: Cannot be penetrated. Semipermeable means that some substances can pass through and others cannot.

Incompatibility: When two or more pesticides cannot be effectively mixed without a loss in activity, an increase in toxicity or hazard to the applicator, or harm to the crop or the environment.

Inert ingredients: The materials in a pesticide formulation which have no pesticide activity.

Inhalation toxicity: A measure of the capacity of a pesticide to cause injury when absorbed through the lungs.

Inhibition: The process of slowing or stopping plant growth with a herbicide.

Inorganic pesticides: Pesticides of a mineral origin that do not contain carbon.

Insecticide: A chemical used to control insects

Integrated pest management (IPM): An ecological approach to pest management in which all available necessary techniques are consolidated into a unified program so that pest populations can be managed to avoid economic damage and minimize adverse effects.

Invert emulsion: An emulsion in which water is dispersed in oil rather than oil in water; invert emulsions are normally quite thick and thus less susceptible to drift.

Invertebrates: A class of animals that lacks a spinal column.

Label: The information printed on or attached to the pesticide container or wrapper.

Labeling: The pesticide label and all additional product information such as brochures and flyers provided by the manufacturer and handouts provided by the dealer.

Larvicide: A pesticide used to kill insect larvae.

LC_{50}: The concentration of an active ingredient in air which is expected to cause death in 50 percent of the test animals so treated. A means of expressing the toxicity of a compound present in air as dust, mist, gas or vapor. It is generally expressed as micrograms per liter as a dust or mist but in the case of a gas vapor as parts per million (ppm).

LD_{50}: The dose of an active ingredient taken by mouth or absorbed by the skin which is expected to cause death in 50 percent of the test animals so treated. If a chemical has an LD_{50} of 10 milligrams per kilogram (mg/kg), it is more toxic than one having an LD_{50} of 100mg/kg.

Leaching: Movement of a substance downward or out of soil as the result of water movement.

Lethal: Causing or capable of causing death.

Life cycles: The progression of stages in the development of an organism.

Material Safety Data Sheets (MSDS): Sheets of information on toxicity, first aid, personal protection and other safety data. MSDS are available from dealers or manufacturers.

Mechanical control: Pest control by physically altering the environment.

Microbiocide: A chemical able to kill microorganisms. Includes bactericides, algaecides, and fungicides.

Microorganism: An organism that can only be seen with a microscope.

Miscible liquids: Two or more liquids that can be mixed and will remain mixed under normal conditions.

Miticide: A chemical used to control mites.

Mode of action: The way in which a pesticide exerts a toxic effect.

Mold: The vegetative phase in the growth of certain fungi displaying long filamentous extensions.

Molluscicide: A chemical used to control snails and slugs.

Mutagenic: Capable of producing genetic change.

Mutation: A change, usually harmful, in inherited genetic material.

Narrow-spectrum pesticide: A pesticide that is effective against only one or a few species; the term is usually applied to insecticides and fungicides.

Natural enemies: The predators and parasites which attack pest species.

Necrosis: Localized death of living tissue such as the death of a certain area of a leaf.

Necrotic: Showing varying degrees of dead areas or spots.

Nematicide: A chemical used to control nematodes.

Nematodes: Small, slender, colorless roundworms that live saprophytically in soil or water or as parasites of plants, animals, or fungi; plant-parasitic nematodes are so small that they cannot be seen except through a microscope.

Neoprene: A synthetic rubber characterized by superior resistance to penetration by pesticides.

Neurotoxic: A pesticide which is harmful to nerve tissue.

Nontarget organisms: All plants, animals and microorganisms other than the intended target(s) of a pesticide application.

Nontarget species: Species not intentionally affected by a pesticide.

Noxious weed: A plant defined as being especially undesirable or troublesome.

Nutrient medium: A specially prepared chemical mixture able to support microorganism growth in the laboratory.

Oil solution: A liquid pesticide formulation in which the active ingredient is dissolved either in oil or some other organic solvent.

Oncogen: A substance having the ability to cause tumors; the tumor may or may not be cancerous.

Oral: Of the mouth; through or by the mouth.

Oral toxicity: Ability of a pesticide to cause injury when taken by mouth.

Organic compounds: Chemicals that contain carbon.

Organic pesticides: Pesticides that contain carbon; most are synthetic, some are derived or extracted from plants.

Organophosphate: A synthetic organic pesticide containing carbon, hydrogen and phosphorus; parathion and malathion are two examples.

Ovicide: A chemical that destroys eggs.

Parasite: A living organism that obtains all or part of its food from other living organisms.

Pathogen: Any disease-producing organism.

Penetrant: An adjuvant that enhances the absorption of a systemic pesticide.

Percolation: Downward seepage of water through the soil.

Perennials: Plants that live for more than two years.

Persistence: A measure of how long a pesticide remains in an active form at the site of application or in the environment.

Pesticide concentrate: A pesticide formulation as it is sold before dilution.

Pesticide interaction: The action or influence of one pesticide upon another and the combined effect of the pesticide on the pest(s) or crop system.

Pesticide registration: The status given to a product to allow for its sale and use as a pesticide by the Environmental Protection Agency or by the state to meet a special local need.

pH: A measure of the acidity or alkalinity of a solution.

Phloem: The tissue in higher plants which transports organic nutrients manufactured in the leaves to other portions of the plant.

Photodecomposition: Degradation of a pesticide by light.

Photosynthesis: The process in green plants of synthesizing carbohydrates from carbon dioxide and water using light energy captured by chlorophyll.

Physiology: The branch of biology that deals with the functions and activities of living organisms.

Phytotoxicity: Injury to plants due to chemical exposure.

Piscicide: A pesticide used to kill or control fish.

Plant growth regulator: A substance that increases, decreases or changes in some manner the normal growth or reproduction of a plant.

Plant pathology: The science that deals with nature and causes of plant disease.

Postemergence: After the emergence of a specified weed or crop.

PPB: Parts per billion.

PPM: Parts per million.

PPT: Parts per trillion.

Predator: An animal that attacks, feeds on, and kills other animals.

Preemergence: Before the emergence of a specified weed or crop.

Propagation: Reproduction by either sexual or asexual means.

Propriety name: Same as brand name.

Protectant: A chemical applied to a plant or animal in anticipation of a pest problem to prevent infection or injury.

Protective equipment: Clothing or any other materials or devices that reduce exposure when using pesticides.

PSI: Pounds per square inch.

Rate: The amount of active ingredient or acid equivalent applied per unit area or other treatment unit. Rates of formulation per area should not be used in scientific publications.

RCRA: The Resource Conservation and Recovery Act; a federal law that regulates the transport, storage, treatment and disposal of hazardous waste.

Restricted entry interval: The length of time that must elapse after a pesticide application before people who are not using personal protective equipment can enter the treated site.

Registered pesticide: A pesticide approved by the Environmental Protection Agency for use as stated on the label or by the state to meet a special local need.

Registration: The regulatory process designated by FIFRA and conducted by the EPA through which a pesticide is legally approved for use.

Residual pesticide: A pesticide that continues to be effective for an extended period of time after application.

Residue: (1) The amount of a pesticide remaining in or on raw farm products or processed foods. (2) Undesirable persistence of a pesticide at the site of application.

Residue tolerance: The maximum amount of a pesticide that may legally remain in or on a raw farm product intended for consumption by people or livestock.

Resistance (pesticide): The genetically acquired ability of an organism to tolerate the toxic effects of a pesticide.

Respiration: (1) The process by which living cells utilize oxygen to transform the energy in food molecules into biologically useful forms. (2) The act of breathing.

Restricted use pesticide: Pesticides designated by the Environmental Protection Agency for restricted use because without additional regulatory restrictions, unreasonable adverse effects on the environment, including injury to the applicator, could occur. A "restricted use" pesticide may be used only by or under the direct supervision of a certified applicator.

Resurgence: A dramatic increase in the population level of a target pest after a pesticide application due to the destruction of its natural enemies by the pesticide; pest numbers may soon surpass pretreatment levels.

Saprophyte: An organism that obtains its food from dead or decaying organic matter.

Scientific name: The Latin name of the genus and species of an organism, designated by taxonomists and universally accepted. Scientific names are often used to avoid confusion which can result from the use of common names which may vary from one area to another.

Scouting (monitoring): Checking a site on a regular basis and in a prescribed manner to determine pest population levels and the extent of pest damage.

Signal words and symbols: Standardized designations of relative levels of toxicity which, by law, must appear on pesticide labels.

Site: The crop, animal or area infested by a pest and to which a pesticide is applied.

Slime: A mucus layer produced by and surrounding an organism, such as bacteria.

Slurry: A thick suspension of a finely-divided pesticide in a liquid.

Solubility: The capacity of a pesticide to dissolve in a specific solvent.

Soluble: Will dissolve in a liquid.

Soluble powder (SP): A finely ground dry pesticide formulation which forms a true solution.

Solution: Mixture of one or more substances in another in which all ingredients are completely dissolved.

Solvent: A liquid which will dissolve a substance to form a solution.

Special local need (SLN): An existing or imminent pest problem within the state which cannot be adequately controlled by the use of any available federally registered pesticide product. The EPA can approve temporary use of a pesticide to alleviate the need.

Species: The basic unit of taxonomic classification designating a group of closely related individuals who are capable of interbreeding.

Spot treatment: Application of a pesticide to small, discrete areas.

Spreader: A chemical that increases the area that a given volume of liquid will cover on a solid or on another liquid.

Standard plate count: See total bacterial count.

Sterility: The inability of a living organism to reproduce.

Sticker: An adjuvant which increases the ability of a pesticide to stick to treated plant surfaces.

Stomach poison: A pesticide that must be swallowed by an animal to be effective. It will not kill on contact.

Stomata: Minute openings on the surfaces of leaves and stems through which gases (e.g. oxygen, carbon dioxide, water vapor) and some dissolved materials pass into and out of plants.

Strain: A subgroup of a species with a common ancestry and distinguishing physiological characteristics.

Surfactant: A chemical that increases the emulsifying, dispersing, spreading and wetting properties of a pesticide.

Susceptible: Capable of being diseased or poisoned; not immune.

Suspension: Finely divided solid particles mixed in a liquid.

Synergism: The combined activity of two or more pesticides that is greater than the sum of their activity when used alone.

Synthetic chemical: A human-made chemical.

Systemic pesticide: A chemical absorbed and translocated within a plant or animal.

Tank mix: A mixture in the spray tank of two or more pesticide products for simultaneous application.

Target organism/pest: The pest at which a particular pesticide or other control method is directed.

Taxonomy: The classification of living organisms into groups based on similarities and relationships.

Thickeners: Drift control agents such as cellulose, gels, and swellable polymers which cause the formation of a greater proportion of large spray droplets.

Tolerance: (1) The ability of a living thing to withstand adverse conditions, such as pest attacks, weather extremes, or pesticides. (2) The amount of a pesticide that may legally remain in or on raw farm products at time of sale.

Total bacteria count: A measure, expressed in organisms/ml, which provides a relative indication of the total bacterial population in a system.

Total plate count: See total bacteria count.

Toxicant: A poisonous chemical.

Toxicity: A measure of the capacity of a pesticide to cause injury.

Toxin: A poisonous substance produced by a living organism.

Trade name: Same as brand name.

Translocation: The internal movement of food, water, minerals or other materials (e.g. pesticides) from one part of a plant to another.

USDA: United States Department of Agriculture.

Vapor pressure: The property which causes a chemical to evaporate. The lower the vapor pressure, the more easily it will evaporate.

Vascular system: The conducting tissue of plants, composed principally of xylem and phloem.

Vegetative reproduction: Production of new plants from vegetative plant parts such as rootstocks, rhizomes, stolons, tubers, cuttings, etc., rather than from seed.

Vertebrate: An animal with a spinal column.

Virus: An obligate parasite often consisting only of a piece of genetic material surrounded by a protein coat. Viruses are so small that they cannot be seen with an ordinary microscope.

Volatility: The degree to which a liquid or solid changes into a gas (vapor) at ordinary temperatures when exposed to air.

Volatile: Evaporates at ordinary temperatures when exposed to air.

Warning: Signal word associated with pesticide products considered moderately toxic.

Water-dispersible granules: A pesticide formulation in which finely-divided powders are formulated into concentrated, dustless granules which form a suspension in water.

Water-soluble concentrate (WS): A liquid pesticide formulation in which the active ingredient is soluble in water and is formulated either with water or another solvent such as alcohol which mixes readily with water.

Weed: An unwanted plant.

Wettable powder (WP or W): A finely-divided, relatively insoluble pesticide formulation in which the active ingredient is combined with an inert carrier such as clay or talc and with a wetting or dispersing agent; a wettable powder forms a suspension rather than a true solution in water.

Wetting agent: A chemical which causes a liquid to contact surfaces more thoroughly.

Xylem: The tissue in higher plants which transports water, dissolved salts, and other materials (e.g. pesticides) from the roots to aerial portions of the plant.

Yeast: The unicellular growth phase of fungi.

APPENDIX A: RESOURCES

You may wish to become involved with organizations affiliated with the aquatic pest management industry or purchase some of these resources to use as references for your work. The following items identified as Extension bulletins may be ordered from the Michigan State University Extension Bulletin Office, (517) 355-0240.

Professional Organizations

The Midwest Aquatic Plant Management Society, Inc.
P.O. Box 100
Seymour, Indiana 47274

The Aquatic Plant Management Society
P.O. Box 2695
Washington, D.C. 20013-2695

The North American Lake Management Society
P.O. Box 217
Merrifield, Virginia 22116

Pesticide Product Information

Agricultural Chemicals Book II – Herbicides. 1989-90 Revision. W. T. Thomson. Thomson Pubications, P.O. Box 9335, Fresno, CA 93791.

Agricultural Chemicals Book III – Fungicides. 1988-89 Revision. W. T. Thomson. Thomson Pubications, P.O. Box 9335, Fresno, CA 93791.

The Herbicide Handbook, 1989. Weed Science Society of America, 309 West Clark Street. Champaign, IL 61820 (1989)

Pesticide Use and Safety

Handbook of Acute Toxicity of Chemicals to Fish and Aquatic Invertebrates, Johnson, Waynon W., and Mack T. Finley. Washington, D.C.: U.S. Department of the Interior Fish and Wildlife Service. Resource Publication 137. 98 pp.

How To Determine Areas and Amount of Aquatic Herbicide To Use, 1991. Videotape, 34 minutes, $10, (IFAS Catalog No. VT-310), IFAS Publications IFAS Building 664, Gainesville, FL 32611-0001.

Calibration – A Field Approach for Aquatic Managers, 1991. Videotape, 35 minutes, $10. (IFAS Catalog No. VT-310), IFAS Publications IFAS Building 664, Gainesville, FL 32611-0001.

Pesticides: How They Work, Human Poisoning Treatments. MSU Extension bulletin E-0789.

Pesticide Emergency Information. MSU Extension bulletin AM-37 or AM-37SP for the spanish version.

SARA Title III: The Farmer's (Applicator's) Responsibilities Under The Emergency Planning and Community Right-To-Know Law. MSU Extension bulletin E-2173.

10 Tips for Laundering Pesticide Soiled Clothing. MSU Extension Bulletion E-2149.

Plant Identification

How To Identify and Control Water Weeds and Algae, 4th Edition, An International Guide to Water Management. 1990. Applied Biochemists, Inc. 5300 West County Line Road, Mequon, WI 53092. U.S. Toll free (800) 558-5106.

A Field Guide to Valuable Underwater Aquatic Plants of the Great Lakes, 1986. Donald Schloesser, U.S. Fish and Wildlife Service Great Lakes Fishery Laboratory and MSU Extension. MSU Extension bulletin E-1902, $3.50.

Aquatic Plant Problems in Recreational Lakes of Southern Michigan. 1977 Extension bulletin E-1135, Michigan State University Extension. $2.

Managing Michigan Ponds for Sport Fishing, Second Edition. 1989. Extension bulletin E-1554, Michigan State University Extension. $2.50.

The Biology of Aquatic Vascular Plants. C.D. Sculthrope. West Ham College of Technology, London. 610 pp.

Aquatic Plant Identification and Herbicide Use Guide; Volume I: Aquatic Herbicides and Application Equipment. Technical report A-88-9, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS 146 pp.

Pest Management – Aquatic

Freshwater Vegetation Management. Dr. Edward O. Gangtad, Thomas Publications, P.O. Box 9335 Fresno, CA 93791.

Water Quality Indicators Guide: Surface Waters. 1989. U.S. Department of Agriculture, Soil Conservation Service, P.O. Box 2890, Washington, D.C. 20013.

Controlling Aquatic Weeds With Sonar. 1990. Videotape, DowElanco, Carmichael Lynch, # ES 9592, 20005/1269.

Nuisance Beaver Control. Department of Natural Resources, Wildlife Division, Mason Building, P.O. Box 30028, Lansing, MI 48909.

Professional Publications

Aquaphyte. Published by Center for Aquatic Plants, Institute of Food and Agriculture Sciences, University of Florida-Gainesville. To subscribe: APRIS, 2183 McCarty Hall, University of Florida, Gainesville, FL 32611. Phone: 904-392-1799. No charge for the publication. Aquaphyte contains current aquatic plant research from around the world.

Aquatics. Magazine published by the Florida Aquatic Plant Management Society. P.O. Box 2695, Washington D.C. 20013-2695, for more information.

Journal of Aquatic Plant Management. Biannual newsletter from the Aquatic Plant Mnagement Society, P.O. Box 2695, Washington D.C. 20013-2695.

The Northern Lakes Manager. Magazine published by the Midwest Aquatic Plant Management Society, Inc. Members of the society recieve a subscription. Contact the Society at P.O. Box 100, Seymour, IN, for more information.

Boating Information

Marine Safety Act, Act 303 PA 1967, as amended.

Federal Requirements for Recreational Boats – Pamphlet, U.S. Department of Transportation, U.S. Coast Guard, 2100 Second St., S.W., Washington, D.C. 20593-0001.

Other Information Services;

International Wildlife Rehabilitation Council
4437 Central Place, Suite B-4
Suisun, CA 94585
(707) 864-1761 – Office
(707) 864-3106 – Fax
(707) 864-1762 – Hotline

Michigan Department of Agriculture (MDA)
Pesticide and Plant Pest Management Division
P.O. Box 30017 Lansing, MI 48909 (517) 373-1087.

Regional MDA Offices:

REGION 1	Room 117 State Office Bldg. Escanaba, MI 49829 (906) 786-5462
REGION 2	701 S. Elmwood Ave., Suite 9 Traverse City, MI 49684-3185 (616) 922-5210
REGION 3	State Office Bldg. 350 Ottawa, N.W. Grand Rapids, MI 49503 (616) 456-6988
REGION 4	Saginaw State Office Bldg. 411-F East Genesee Saginaw, MI 48607 (517) 758-1778
REGION 5	4032 M-139, Bldg. 116 St. Joseph, MI 49805-9647 (616) 428-2575
REGION 6	611 W. Ottawa North Ottawa Bldg. Lansing, MI 48933 517) 373-1087
REGION 7	Lahser Center Bldg. 26400 Lahser Road Southfield, MI 48034 (313) 356-1701

Michigan Department of Natural Resources

Land and Water Management
Division Inland Lakes Management Unit
Box 30028
Lansing, Michigan 48909
Phone: (517) 373-8000

Department of Natural Resources Regional Offices
Region I DNR Headquarters
1990 U.S. 41, South
Marquette, MI 49855
(906) 228-6561

Region II DNR Headquarters
Box 128
8718 N. Roscommon Rd.
Roscommon, MI 48653

Region III DNR Headquarters
Box 30028
Lansing, MI 48909
(517) 322-1300

Michigan State University Extension county- and campus-based personnel.

National Wildlife Rehabilitators Association
NWRA Central Office
Carpenter Nature Center
12805 St. Croix Trail
Hastings, MN 55033
(612) 437-9194 – Office
(612) 438-2908 – Fax

DNR

STATE OF MICHIGAN
DEPARTMENT OF NATURAL RESOURCES
LAND AND WATER MANAGEMENT DIVISION

APPLICATION FOR PERMIT FOR CHEMICAL TREATMENT TO CONTROL NUISANCE AQUATIC PLANT AND/OR ALGAE GROWTH

Pursuant to Act No. 368 of the Public Acts of 1978 and the rules promulgated thereunder application is made by the undersigned for a permit to chemically treat the waters described below for the control of nuisance aquatic plant and/or algae growth.

SECTION I GENERAL INFORMATION

APPLICANT	WATERS TO BE TREATED
NAME	NAME OF LAKE, POND, STREAM
NUMBER AND STREET ADDRESS	COUNTY
CITY, STATE, ZIP CODE	TOWNSHIP NAME · TOW[illegible] · SECTION NO.
TELEPHONE NO.	OTHER INFORMA[illegible]R PRECISE [illegible]ON
IF APPLICANT IS LICENSED CHEMICAL APPLICATOR, PROVIDE LICENSE NUMBER	[illegible]E [illegible] LA[illegible] [illegible]OND[illegible] KNOWN ACRES

SECTION II TREATMENT INFOR[illegible]ION

1. DIMENSION OF TOTAL TREATMENT [illegible]
   length ______ [illegible] ______ ft. average depth ______ ft.
   total surface area prop[illegible]d for [illegible]eatme[illegible] (o[illegible]own) ______ acres (1 acre = 43,560 square feet)

2. NAME OF EACH CHE[illegible] REQUESTED	[illegible]QUI[illegible] OR [illegible]AN[illegible]LAR	[illegible]ARGET PLANT(S) AND/OR ALGAE	DIMENSION OR AREA OF TREATMENT	(OPTIONAL) AMOUNT OF EACH CHEMICAL	APPROXIMATE DATE(S) OF APPLICATION
	☐ L ☐ G				
	☐ L ☐ G				
	☐ L ☐ G				
	☐ L ☐ G				
	☐ L ☐ G				
	☐ L ☐ G				
	☐ L ☐ G				

SAMPLE

SECTION III TREATMENT MAP

Provide 2 copies of a map or accurate drawing of the waterbody to be treated; indicate the location of the treatment area. Include any additional information required in Sections III and IV and as detailed in the instructions. This map must be of sufficient quality to allow the DNR to evaluate the proposed treatment, or the application may be returned (*see instructions*).

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SECTION IV SAFETY AND PUBLIC HEALTH INFORMATION

If there is a shallow well within 30 ft. of the shoreline, allow 100 ft. between the treatment area and the well, if using Diquat, Rodeo, or Sonar. Allow 500 ft. between the treatment area and the well if using 2,4-D or endothall.

1. What are the methods of application, safety precautions, and qualifications of personnel handling chemicals?

2. What methods will be used to minimize drift of the chemical(s) outside of the treatment area?

3. Are there any **major** water users (crop irrigators, livestock waterers, municipalities, industries, etc.) within 1 mile downstream of the treatment area on the outlet stream? — YES ☐ NO ☐
   If "YES", identify location on the treatment map and indicate th[illegible] type of water user.

4. If proposing to treat a lake, is it an impoundment [illegible] do[illegible] ha[illegible] water level control structure which artificially rai[illegible] th[illegible]el [illegible] the [illegible] — YES ☐ NO ☐

   Is there water flow through the outlet? — YES ☐ NO ☐
   If "YES", what is the rate of flow, [illegible] ______ cfs.

5. What is the drinking water supp[illegible]esiden[illegible] in [illegible] proposed treatment area? Municipal ☐ Priv[illegible] ☐

6. What is located i[illegible] of the outlet? (i.e. wetland, residential area, e[illegible]

7. If proposing to treat [illegible] lake or pond, what is the distance between the intended treatment ar[illegible]nd the lake or pond outlet? ______ ft.

SECTION V ENVIRONMENTAL INFORMATION

1. Will the proposed treatment involve 50% or more of the shoreline (if treating a lake or pond)? — YES ☐ NO ☐
   If "YES", provide information required below question 3.

2. Will the proposed treatment involve 10 acres or more of the waterbody? — YES ☐ NO ☐
   If "YES", provide information required below question 3.

3. Will the proposed treatment take place farther than 300 ft. from shore? — YES ☐ NO ☐
   If "YES", provide the information required below.

IF THE ANSWER TO <u>ANY</u> OF THE ABOVE THREE QUESTIONS IS "YES", PROVIDE THE FOLLOWING:

a) a justification for the treatment (see instructions).

Application for Permit for Chemical Treatment to Control Nuisance Aquatic Plant and/or Algae Growth, Page 2.

b) the treatment map must show the submerged vegetation distribution of the entire waterbody, indicating the location of the proposed treatment area(s) and the submerged vegetation that will remain uneffected by the treatment.

4. Will the proposed treatment involve application of chemical(s) to submerged vegetation within or adjacent to a wetland? YES ☐ NO ☐
If "YES", provide information required below question 5.

5. Will the proposed treatment involve application of chemical(s) to emergent vegetation? YES ☐ NO ☐
If "YES", provide information required below.

IF THE ANSWER TO EITHER OF THE ABOVE TWO QUESTIONS IS "YES", PROVIDE THE FOLLOWING:

a) a justification for the treatment (see instructions).

b) an explanation of the chemical application methods that will be [illegible] to prev[illegible] to non-target plants.

c) the treatment map must sho[illegible]xisting [illegible]tion of the waterbody, indicating vegetation proposed for chemical treatment and [illegible]tion [illegible]ill remain uneffected by the treatment.

SECTION VI RESPONSI[illegible] FOR UNDERTAKING TREATMENT

If the treatment will involve the properties of more than one riparian, this section must be completed. Choose option 1 or 2. If only one property will be involved in the treatment, skip this section and proceed to Section VII.

Option 1. Treatment By/For A Lake Association or Group of Individual Property Owners

Name of Lake Association	Name of Local Person Responsible for Organizing the Treatment
Title of Responsible Person, if Applicable	Number and Street Address
Telephone Number	City, State, Zip Code
Name, Address, and Telephone Number of Four Additional Persons With Knowledge of the Treatment.	

Application for Permit for Chemical Treatment to Control Nuisance Aquatic Plant and/or Algae Growth, Page 3.

Option 2. Treatment By/For A Governmental Unit

Name of Governmental Unit	Name of Local Person Responsible for Organizing the Treatment
Title of Responsible Person, if applicable	Number and Street Address
Telephone Number	City, State, Zip Code

Name, Address, and Telephone Number of Four Additional Persons With Knowledge of the Treatment.

SAMPLE

SECTION VII CERTIFICATION

I certify that the preceding statements made by me are, to the best o[illegible] knowled[illegible]rre[illegible]nd it is understood that a permit, if granted, can be revoked before or at the tim[illegible]trea[illegible] by a r[illegible]ntative of the Michigan Department of Natural Resources if any of the informatio[illegible]bm[illegible] in [illegible]ppl[illegible]at[illegible] is incorrect, or if in their opinion the public interest is jeopardized. If a permit i[illegible]gr[illegible] I [illegible]e to [illegible] responsibility for planning and carrying out the permitted treatment, and agree to [illegible]nnif[illegible]ve harm[illegible]s the State of Michigan against any and all actions, claims, briefs, demands, dama[illegible] c[illegible]oss[illegible]xpenses in any manner resulting from or arising out of the permitted treatment. It is und[illegible]rmis[illegible]s given for representatives of the Michigan Department of Natural Resources to [illegible]ter upo[illegible]r[illegible] fo[illegible]e purpose of inspecting the chemical treatment. Also, I agree to submit the post-tre[illegible] data r[illegible]. I [illegible]O HEREBY CERTIFY THAT THE PROPERTIES TO BE TREATED ARE EITHER UN[illegible]R MY[illegible] CON[illegible]RO[illegible] AND/OR UNDER THE LEGAL CONTROL OF PARTIES WHO HAVE GRANTED ME P[illegible]SION [illegible]O [illegible]E T[illegible]ATMENT, OR I REPRESENT A UNIT OF GOVERNMENT WITH AUTHORITY TO DO [illegible]E TREATM[illegible].
Prior to carrying out th[illegible] che[illegible]ical [illegible]eatment I will have obtained permission from all of the property owners within the treatment a[illegible] [illegible]emical treatment of their bottomland property. YES ☐ NO ☐

Signature ______________________ Date ______________

Title ______________________

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Application for Permit for Chemical Treatment to Control Nuisance Aquatic Plant and/or Algae Growth, Page 4.

STATE OF MICHIGAN
DEPARTMENT OF NATURAL RESOURCES
LAND AND WATER MANAGEMENT DIVISION

PERMIT
FOR
PESTICIDE APPLICATION TO SURFACE WATERS OF THE STATE OF MICHIGAN

(Pursuant to Act No. 368 of the Public Acts of 1978 and rules promulgated thereunder)

PERMIT NO.
DATE ISSUED
This permit is valid only through December, 31, 19 ____

WATERS TO BE CHEMICALLY TREATED
NAME OF WATERBODY
COUNTY IN WHICH WATERS ARE LOCATED

Based upon information supplied in the application, permission is hereby given to the above applicant to chemically treat the waters described herein for the following:

☐ AQUATIC PLANT MANAGEMENT ☐ SWIMMERS' ITCH CONTROL ☐ OTHER ____

Treatment shall be restricted to the TYPES OF CHEMICALS, RATES OF APPLICATION, AND TOTAL QUANTITIES specified below. Treatment shall also be restricted to the AREAS which are described by the application and which are either under the legal control of the applicant or under the legal control of parties who have granted the applicant PERMISSION to do the treatme[nt].

CHEMICAL	RATE OF APPLICATION	[illegible] AMOUNT TO BE APPLIED

Issuance of this permit is subject to the … conditions (checked) which are explained on the reverse side or below.

☒ 1. ☐ 2. ☐ 3. ☐ 4. ☐ …er (See below)

DNR OFFICE (and location) TO BE …	TELEPHONE NUMBER
OTHER CONDITIONS:	

SPECIFIC POSTING RESTRICTIONS — CONDITION NO. 4. Time following treatments that water may NOT be used.			
CHEMICAL OR ACTIVE INGREDIENT	NO SWIMMING OR BATHING	NO HOUSEHOLD USES, IRRIGATION, ANIMAL WATERING OR SIMILAR USES	NO TAKING FISH FOR FOOD OR FEED
Diquat	One Day	14 Days	does not apply
Endothall	One Day	14 Days	3 Days
2,4-D	One Day	Indefinite	does not apply
Glyphosate	One Day	does not apply	does not apply
Other			

NOTE: When more than one chemical is applied, restrictions are combined and the most stringent of each category applies (e.g.: Diquat and endothall: one day no swimming, 2 weeks no household uses etc., 3 days no fish uses.)
NOTE Posting is NOT required when copper products are used alone. There are no restrictions on the use of treated water, however no swimming is recommended in treatment areas for 24 hours following treatment for swimmers' itch control.

The treatment report must be completed and returned to: Department of Natural Resources, Land and Water Management Division, Inland Lake Management Unit, Box 30028, Lansing, Michigan 48909 three to four weeks following treatment. The report must be returned before November 1, even if treatment is not undertaken. Failure to comply with permit conditions is a violation of Act No 368 of the Public Acts of 1978 and the rules promulgated thereunder.

By ____________________ Prepared by ____________________
For Director, Department of Natural Resources

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Permit for Pesticide Application to Surface Waters of the State of Michigan, Side 1.

CONDITIONS OF PERMIT

Condition No. 1.

The issuance of this permit does not remove the necessity of contacting adjacent riparian owners so as to apprise them of the proposed action and securing their concurrence; and at least seven days prior to treatment, the applicant shall advise them in writing of the details of the treatment and of any hazards and restrictions which may result from the use of such chemicals or treated water. Nor does this permit relieve the applicant from adhering to all label restrictions of the pesticide product(s) specified. It is the responsibility of the applicant to immediately contact the appropriate office of the Department of Health or the Department of Natural Resources if any human injury or illness, or unusual fish or wildlife damage occurs in association with a chemical treatment. Upon request of the Department of Natural Resources or its representatives, the applicant shall supply a sample of the herbicide(s) that will be or is being used. The permit is further conditioned by the provision that any special conditions specified are followed.

Condition No. 2.

The Department of Natural Resources Office, specified on the permit, must be notified as to the precise time chemicals to be used and location of treatment at least 2 working days prior to each actual treatment. Notification must be during normal working hours (8:00 AM to 5:00 PM Monday through Friday).

Condition No. 3.

Chemical treatment may **NOT** proceed unless a Department of Natural Resources representative is present.

Condition No. 4.

Posting Requirements: Completed Department-approved signs must be posted along the shoreline of the treatment area not more than 100 feet apart. Each sign must include the "SPECIFIC POSTING RESTRICTIONS" listed on the face of this permit. Riparian lands adjacent to the area shall also be posted, if permitted by the owners. For treatment of areas in excess of 2 acres using products which do not restrict fishing and for treatments of any size using products which restrict fishing, signs shall also be posted conspicuously at all public access sites, boat launching areas, and private and public parks, if permitted by their managers or owners. If posting sites are not adjacent to the treatment area, signs shall clearly indicate the location of the treatment area.

[illegible]

Initiation of any work on the permitted project confirms the permittee's acceptance and agreement to comply with all terms and conditions of this permit. Noncompliance with these terms and conditions, and/or the initiation of other regulated activities not [illegible] authorized by this permit shall be cause for the modification, suspension or revocation of this permit, in whole or in part. Further the Department of Natural Resources may initiate criminal and/or civil proceedings as may be deemed necessary to correct project deficiencies to protect natural resource values, and secure compliance with statutes.

LIABILITY

Permittee covenants not to sue the State of Michigan, or any of its departments, boards, commissions, officers, employees or agents for any claim whether legal or equitable, arising under, or in any manner related, to the privileges granted in this permit. Permittee hereby releases, waives, and discharges the State of Michigan and all of its departments, boards, commissions, officers, employees, and agents from any and all liability to Permittee, its officers, employees and agents, for all losses, injury, or damage to person or property, or death, and any claims or demands therefor, arising under, or in any manner related to, the privileges granted in this permit, whether caused by the State of Michigan, or any of its departments, agencies, boards or commissions, or any of their officers, employees, or agents.

INDEMNIFICATION

Permittee covenants and agrees to indemnify and save harmless the State of Michigan, and all of its departments, agencies, boards, commissions, officers, employees, and agents from any and all claims, demands, judgments, and expenses, including attorney fees, for any and all loss, damage, or injury to person or property, or death arising under, or in any manner related to (a) this permit, the activities authorized by this permit, or (c) the use or occupancy of the premises that are the subject of this permit as well as any other state-owned lands. This indemnification and save harmless agreement is intended to and shall extend to all loss, damage, or injury to person or property, or death, proximately caused, in whole or in part, by the negligence or other tortious conduct of the State of Michigan, its departments, boards, commissions, officers, employees, or agents.

Permit for Pesticide Application to Surface Waters of the State of Michigan, Side 2.

APPENDIX C:

Convenient Conversion Factors

Multiply	By	To Get
Acres	0.405	Hectares
Acres	4,047.0	Square Meters
Acres	4,840.0	Square Yards
Acres-feet	43,560.0	Square feet
Acre-feet	1,233.49	Cubic Meters
Acre-feet	43,560.0	Cubic Feet
Acre-feet	325,850.58	Gallons
Bushels	0.0461	Cubic yards
Bushels	1.2437	Cubic feet
Bushels	4.0	Pecks
Bushels	32.0	Quarts (dry)
Bushels	35.24	Liters
Bushels	64.0	Pints (dry)
Bushels	2,150.42	Cubic inches
Centimeters	0.3627	Inches
Centimeters	0.01	Meters
Centimeters	10.0	Millimeters
Cubic centimeters	0.0610	Cubic inches
Cubic centimeters	0.03381	Ounces (liquid)
Cubic centimeters	1.0	Milliliters of water
Cubic centimeters	1.0	Grams of water
Cubic feet	0.0283	Cubic meters
Cubic feet	0.0370	Cubic yards
Cubic feet	0.8040	Bushels
Cubic feet	7.4805	Gallons
Cubic feet	25.71	Quarts (dry)
Cubic feet	28.32	Liters
Cubic feet	29.92	Quarts (liquid)
Cubic feet	51.42	Pints (dry)
Cubic feet	59.84	Pints (liquid)
Cubic feet	62.4	Pounds of water
Cubic feet	1,728.0	Cubic inches
Cubic feet	28,317.0	Cubic centimeters
Cubic meters	1.308	Cubic yards
Cubic meters	35.31	Cubic feet
Cubic meters	264.2	Gallons
Cubic meters	1,000.0	Liters
Cubic meters	1,057.0	Quarts (liquid)
Cubic meters	2,113.0	Pints (liquid)
Cubic meters	61,023.0	Cubic inches
Cubic meters	1,000,000.0	Cubic centimeters
Cubic inches	0.000016	Cubic meters
Cubic inches	0.0005	Bushels
Cubic inches	0.0006	Cubic feet
Cubic inches	0.0019	Pecks (dry)

Multiply	By	To Get
Cubic inches	0.0037	Gallons (dry)
Cubic inches	0.0043	Gallons (liquid)
Cubic inches	0.0149	Quarts (dry)
Cubic inches	0.0164	Liters
Cubic inches	0.0173	Quarts (liquid)
Cubic inches	0.0298	Pints (dry)
Cubic inches	0.0346	Pints (liquid)
Cubic inches	0.0361	Pounds of water
Cubic inches	0.5540	Ounces (liquid)
Cubic inches	16.3872	Cubic centimeters
Cubic yards	0.7646	Cubic meters
Cubic yards	21.71	Bushels
Cubic yards	27.0	Cubic feet
Cubic yards	202.0	Gallons (liquid)
Cubic yards	807.9	Quarts (liquid)
Cubic yards	1,616.0	Pints (liquid)
Cubic yards	7,646.0	Liters
Cubic yards	46,656.0	Cubic inches
Cups	0.25	Quarts (liquid)
Cups	0.5	Pints (liquid)
Cups	8.0	Ounces (liquid)
Cups	16.0	Tablespoons
Cups	48.0	Teaspoons
Cups	236.5	Milliliters
Feet	0.3048	Meters
Feet	0.3333	Yards
Feet	12.0	Inches
Feet	30.48	Centimeters
Feet per minute	0.01136	Miles per hour
Feet per minute	0.01667	Feet per second
Feet per minute	0.01829	Kilometers per hour
Feet per minute	0.3048	Meters per minute
Feet per minute	0.3333	Yards per minute
Feet per minute	60.0	Feet per hour
Gallons	0.00378	Cubic meters
Gallons	0.1337	Cubic feet
Gallons	3.785	Liters
Gallons	4.0	Quarts (liquid)
Gallons	8.0	Pints (liquid)
Gallons	8.337	Pounds
Gallons	128.0	Ounces (liquid)
Gallons	231.0	Cubic inches (liquid)
Gallons	269.0	Cubic inches (dry)
Gallons	3,785.0	Cubic centimeters

Multiply	By	To Get
Gallons of water	0.0038	Cubic meters
Gallons of water	0.0049	Cubic yards
Gallons of water	0.1337	Cubic feet
Gallons of water	3.7853	Kilograms
Gallons of water	8.3453	Pounds of water
Gallons of water	3,785.3446	Grams
Grains	0.0648	Grams
Grams	0.001	Kilograms
Grams	0.0022	Pounds
Grams	0.0353	Ounces
Grams	15.53	Grains
Grams	1,000.0	Milligrams
Grams per liter	10.0	Percent
Grams per liter	1,000.0	Parts per million
Hectares	2.47	Acres
Hectares	10,000.0	Square meters
Hectares	11,954.8	Square yards
Hectares	107,593.2	Square feet
Inches	0.0254	Meters
Inches	0.02778	Yards
Inches	0.08333	Feet
Inches	2.54	Centimeters
Kilograms	0.0011	Tons
Kilograms	2.205	Pounds
Kilograms	35.28	Ounces
Kilograms	1,000.0	Grams
Kilometers	0.6214	Miles
Kilometers	1,000.0	Meters
Kilometers	1,093.611	Yards
Kilometers	3,280.833	Feet
Kilometers per hour	0.6214	Miles per hour
Kilometers per hour	16.6667	Meters per minute
Kilometers per hour	18.2268	Yards per minute
Kilometers per hour	54.6806	Feet per minute
Liters	0.001	Cubic meters
Liters	0.0353	Cubic feet
Liters	0.2642	Gallons (liquid)
Liters	1.0	Kilograms of water
Liters	1.057	Quarts (liquid)
Liters	2.113	Pints (liquid)
Liters	33.8143	Ounces
Liters	61.02	Cubic inches
Liters	1,000.0	Cubic centimeters
Liters	1,000.0	Grams of water

Multiply	By	To Get
Meters	0.001	Kilometers
Meters	1.094	Yards
Meters	3.281	Feet
Meters	39.37	Inches
Meters	100.0	Centimeters
Meters	1,000.0	Millimeters
Metric tons	1.1	Tons (U.S.)
Metric tons	1,000.0	Kilograms
Metric tons	2,204.6	Pounds
Metric tons	1,000,000.0	Grams
Miles	1.6093	Kilometers
Miles	1,609.3	Meters
Miles	1,760.0	Yards
Miles	5,280.0	Feet
Miles per hour	1.467	Feet per second
Miles per hour	1.6093	Kilometers/ hour
Miles per hour	26.8217	Meters per minute
Miles per hour	29.3333	Yards per minute
Miles per hour	88.0	Feet per minute
Miles per minute	26.82	Meters per second
Miles per minute	29.333	Yards per second
Miles per minute	88.0	Feet per second
Milliliters	0.00105	Quarts (liquid)
Milliliters	0.0021	Pints (liquid)
Milliliters	0.0042	Cups (liquid)
Milliliters	0.0338	Ounces (liquid)
Milliliters	0.0676	Tablespoons
Milliliters	0.2029	Teaspoons
Milliliters	1.0	Cubic centimeters of water
Milliliters	1.0	Grams of water
Ounces (liquid)	0.00781	Gallons
Ounces (liquid)	0.03125	Quarts (liquid)
Ounces (liquid)	0.0625	Pints (liquid)
Ounces (dry)	0.0625	Pounds
Ounces (liquid)	0.125	Cups (liquid)
Ounces (liquid)	1.805	Cubic inches
Ounces (liquid)	2.0	Tablespoons
Ounces (liquid)	6.0	Teaspoons
Ounces (dry)	28.3495	Grams
Ounces (liquid)	29.573	Milliliters
Ounces (dry)	437.5	Grains
Parts / million (PPM)	0.0001	Percent
Parts per million	0.001	Liters/cubic meter
Parts per million	0.001	Grams per liter

Multiply	By	To Get
Parts per million	0.001	Milliliters per liter
Parts per million	0.013	Ounces per 100 gallons of water
Parts per million	0.0584	Grains per US gallon
Parts per million	0.3295	Gallons per acre-foot of water
Parts per million	1.0	Milligrams/ liter
Parts per million	1.0	Milligrams per kilogram
Parts per million	1.0	Milliliters per cubic meter
Parts per million	2.7181	Pounds per acre-foot of water
Parts per million	8.345	Pounds per million gallons of water
Pecks	0.25	Bushels
Pecks	8.0	Quarts (dry)
Pecks	16.0	Pints (dry)
Pecks	537.605	Cubic inches
Percent (%)	1.33	Ounces (dry) per gallon of water
Percent	8.34	Pounds per 100 gallons of water
Percent	10.00	Grams per kilogram
Percent	10.00	Grams per liter
Percent	10,000.00	Parts per million
Pints (dry)	0.0156	Bushels
Pints (dry)	0.0625	Pecks
Pints (liquid)	0.125	Gallons
Pints (liquid)	0.4735	Liters
Pints (liquid)	0.5	Quarts (liquid)
Pints (dry)	0.5	Quarts (dry)
Pints (liquid)	2.0	Cups
Pints (liquid)	16.0	Ounces (liquid)
Pints (liquid)	28.875	Cubic inches (liquid)
Pints (dry)	33.6003	Cubic inches (dry)
Pounds	0.0005	Tons
Pounds	0.4535	Kilograms
Pounds	16.0	Ounces
Pounds	453.5924	Grams
Pounds	7,000.0	Grains
Pounds of water	0.0160	Cubic feet
Pounds of water	0.1198	Gallons
Pounds of water	0.4536	Liters
Pounds of water	27.693	Cubic inches
Quarts (liquid)	0.00094	Cubic meters
Quarts (liquid)	0.0012	Cubic yards

Multiply	By	To Get
Quarts (dry)	0.03125	Bushels
Quarts (liquid)	0.0334	Cubic feet (liquid)
Quarts (dry)	0.0389	Cubic feet (dry)
Quarts (dry)	0.125	Pecks
Quarts (liquid)	0.25	Gallons (liquid)
Quarts (liquid)	0.9463	Liters
Quarts (liquid)	2.0	Pints (liquid)
Quarts (dry)	2.0	Pints (dry)
Quarts (liquid)	2.0868	Pounds of water
Quarts (liquid)	4.0	Cups
Quarts (liquid)	32.0	Ounces (liquid)
Quarts (liquid)	57.75	Cubic inches (liquid)
Quarts (dry)	67.20	Cubic inches (dry)
Square feet	0.000009	Hectares
Square feet	0.000023	Acres
Square feet	0.0929	Square meters
Square feet	0.1111	Square yards
Square feet	144.0	Square inches
Square inches	0.00064	Square meters
Square inches	0.00077	Square yards
Square inches	0.00694	Square feet
Sq. kilometers	0.3861	Square miles
Sq. kilometers	100.0	Hectares
Sq. kilometers	247.104	Acres
Sq. kilometers	1,000,000.0	Square meters
Sq. kilometers	1,195,982.7	Square yards
Sq. kilometers	10,763,865.0	Square feet
Square meters	0.0001	Hectares
Square meters	1.308	Square yards
Square meters	10.765	Square yards
Square meters	1,549.9669	Square feet
Square miles	2.5899	Square kilometers
Square miles	258.99	Hectares
Square miles	640.0	Acres
Square miles	2,589,735.5	Square meters
Square miles	3,097,600.0	Square yards
Square miles	27,878,400.0	Square feet
Square yards	0.00008	Hectares
Square yards	0.00021	Acres
Square yards	0.8361	Square meters
Square yards	9.0	Square feet
Square yards	1,296.0	Square inches
Tablespoons	0.0625	Cups
Tablespoons	0.5	Ounces
Tablespoons	3.0	Teaspoons
Tablespoons	15.0	Milliliters

Multiply	By	To Get
Teaspoons	0.0208	Cups
Teaspoons	0.1667	Ounces
Teaspoons	0.3333	Tablespoons
Teaspoons	5.0	Milliliters
Tons	0.907	Metric ton
Tons	907.1849	Kilograms

Multiply	By	To Get
Tons	2,000.0	Pounds
Tons	32,000.0	Ounces
Yards	0.000568	Miles
Yards	0.9144	Meters
Yards	3.0	Feet
Yards	36.0	Inches

(PLEASE POST IN AN APPROPRIATE PLACE)

PESTICIDE EMERGENCY INFORMATION

For any type of an emergency involving a pesticide, the following Emergency Information Centers should be contacted immediately for assistance.

Current as of June 1993

Human Pesticide Poisoning

Eastern Half of Michigan

(313) 745-5711

Poison Control Center

Children's Hospital of Michigan
3901 Beaubien
Detroit, MI 48201

Western Half of Michigan

Contact local hospital emergency room.

Upper Peninsula of Michigan

within Marquette city proper:

****(906) 225-3497***

Upper Peninsula only:

****1-800-562-9781***

U.P. Poison Control Center

Marquette General Hospital
420 West Magnetic Street
Marquette, MI 48955

Special Pesticide Emergencies

Animal Poisoning

Your veterinarian:

Phone No. ____________________

or

Animal Health Diagnostic Laboratory (Toxicology) Michigan State University:

(517) 355-0281

Pesticide Fire

Local fire department:

Phone No. ____________________

and

Fire Marshal Division, Michigan State Police:

(517) 322-1924

Traffic Accident

Local police department or sheriff's department:

Phone No. ____________________

and

Operations Division, Michigan State Police:

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

Environmental Pollution

Pollution Emergency Alerting System (PEAS}, Michigan Department of Natural Resources:

Phone No. ____________________

and

For environmental emergencies:

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

Pesticide disposal information

Michigan Department of Natural Resources. Waste Management Division.

(517) 373-2730

National Pesticide Telecommunications Network

Provides advice on recognizing and managing pesticide poisoning, toxicology, general pesticide information and emergency response assistance, Funded by EPA, based at Texas Tech University Health Services Center.

1-800-858-7378

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

Michigan State University Extension

(Revised June 1993 — Destroy previous editions)

Revised by
Larry G. Olsen
Pesticide Education Coordinator

MICHIGAN STATE UNIVERSITY EXTENSION

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